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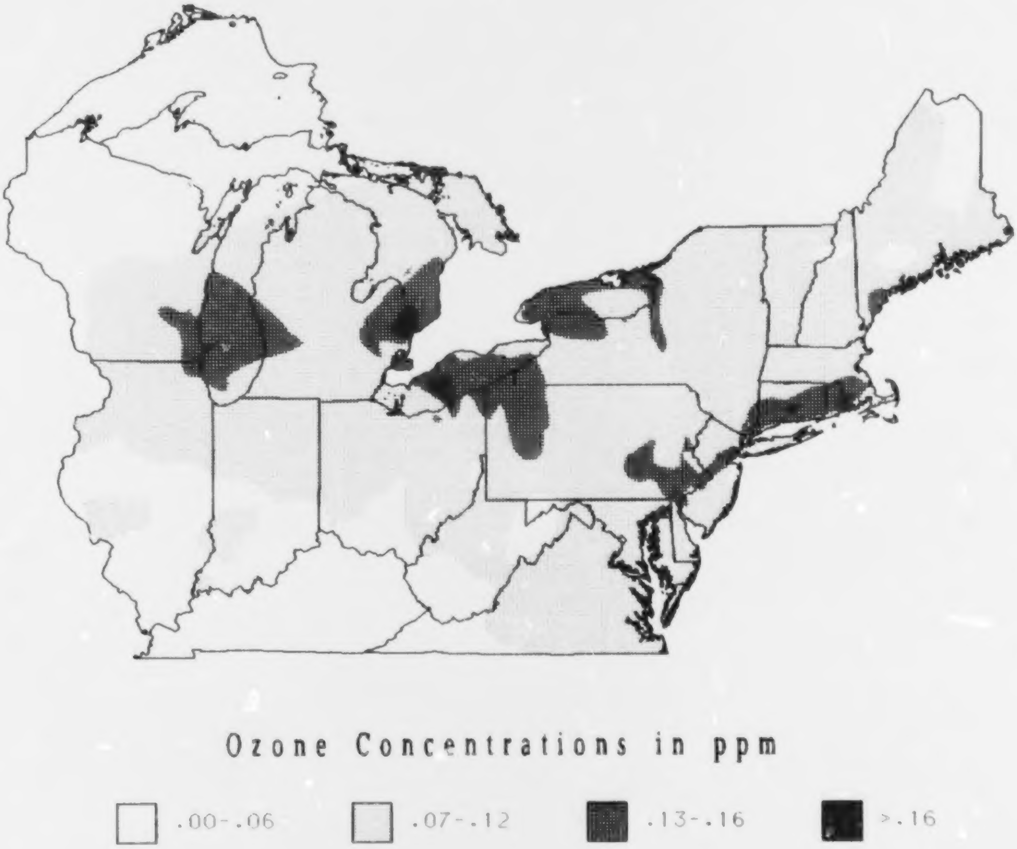
Ozone Concentrations in ppm
□ .00-.06
▨ .07-.12
▩ .13-.16
■ >.16

MAXIMUM ONE HOUR OZONE FOR JUNE 19, 1987

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16. ABSTRACT

This report presents national and regional trends in air quality from 1978 through 1987 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air pollution trends were also examined for the 5-year period (1983-87). Both national and regional trends in each of these pollutants are examined. National air quality trends are also presented for both the National Air Monitoring Sites (NAMS) and other site categories. In addition to ambient air quality, trends are also presented for annual nationwide emissions. These emissions are estimated using the best available engineering calculations; the ambient levels presented are averages of direct measurements.

This report also includes a section, Air Quality Levels in Metropolitan Statistical Areas (MSAs). Its purpose is to provide interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs with data in 1987.

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TRENDS REPORT, 1987

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Research Triangle Park, North Carolina 27711

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About the Cover: Isopleths of ozone daily maximum 1-hour concentrations for June 19, 1987.

PREFACE

This is the fifteenth annual report of air pollution trends issued by the U. S. Environmental Protection Agency. The report is prepared by the Technical Support Division and is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to Dr. Thomas C. Curran, (MD-14) U. S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina 27711.

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Also deserving special thanks are Sue Kimbrough for the emission trend analyses, Tom Furmanczyk of Environment Canada for the 1987 ozone data from Ontario, William Ivey for computer mapping support and David Henderson and Coe Owen of EPA Region IX for providing us with their software to generate the air quality maps of the United States used in this report.

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NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1987

EXECUTIVE SUMMARY

NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1987

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Air pollution in the United States continues to exhibit considerable progress over the years, offset by concerns that many areas still do not meet applicable air quality standards. These National Ambient Air Quality Standards (NAAQS) have been promulgated by the U. S. Environmental Protection Agency (EPA) to protect public health and welfare. There are two types of NAAQS, primary and secondary. Primary standards are designed to protect public health, while secondary standards protect public welfare, including effects of air pollution on vegetation, materials and visibility. This report focuses on comparisons with the primary standards in effect in 1987 to examine changes in air pollution levels over time, and to summarize current air pollution status. There are six pollutants that have NAAQS: particulate matter (formerly as total suspended particulate (TSP) and now as PM_{10} which emphasizes the smaller particles), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and lead (Pb). It is important to note that the discussions of ozone in this report refer to ground level, or tropospheric, ozone and not to stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern.

Almost 102 million people in the U.S. reside in counties which exceeded at least one air quality standard during 1987. Figure 1-1 displays these totals for each individual pollutant, and it is apparent why ground level ozone is viewed as our most pervasive ambient air pollution problem. The 88.6 million people living in counties that exceeded the ozone standard in 1987 are greater than the total for the other five pollutants.

For the 10-year period (1978 through 1987) improvements were seen nationally for all six pollutants: TSP, SO_2, CO, NO_2, O_3 and Pb. Similar improvements have been documented in earlier air quality trends reports issued by EPA.[1-14] This 1987 report requires that 10-year trend sites have data for at least 8 of these years. To incorporate data from newer sites that began operation in the 1980s, trends are also presented for the 5-year period (1983-87). Because of the interest in ozone levels during the summer of 1988, a preliminary estimate is given of the impact of 1988 on ozone trends.

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The trends in ambient air quality that follow are presented as boxplots, which display the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average (Figure 1-2). The 5th, 10th and 25th percentiles depict the "cleaner" sites, while the 75th, 90th and 95th depict the "higher" sites and the median and average describe the "typical" sites. For example, the 90th percentile means that 90 percent of the sites had concentrations less than or equal to that value, and only 10 percent of the sites had concentrations that were higher. The use of the boxplots allow us simultaneously to compare trends in the "cleaner", "typical" and "higher" sites.

The ambient air quality trends presented in this report are based upon actual direct measurements. These air quality trends are supplemented by trends for nationwide emissions, which are based upon the best available engineering calculations. Chapter 4 of this report includes a detailed listing of selected 1987 air quality summary statistics for every metropolitan statistical area (MSA) in the nation and maps highlighting the largest MSAs. Chapter 5 presents 1983-87 trends for fourteen cities.

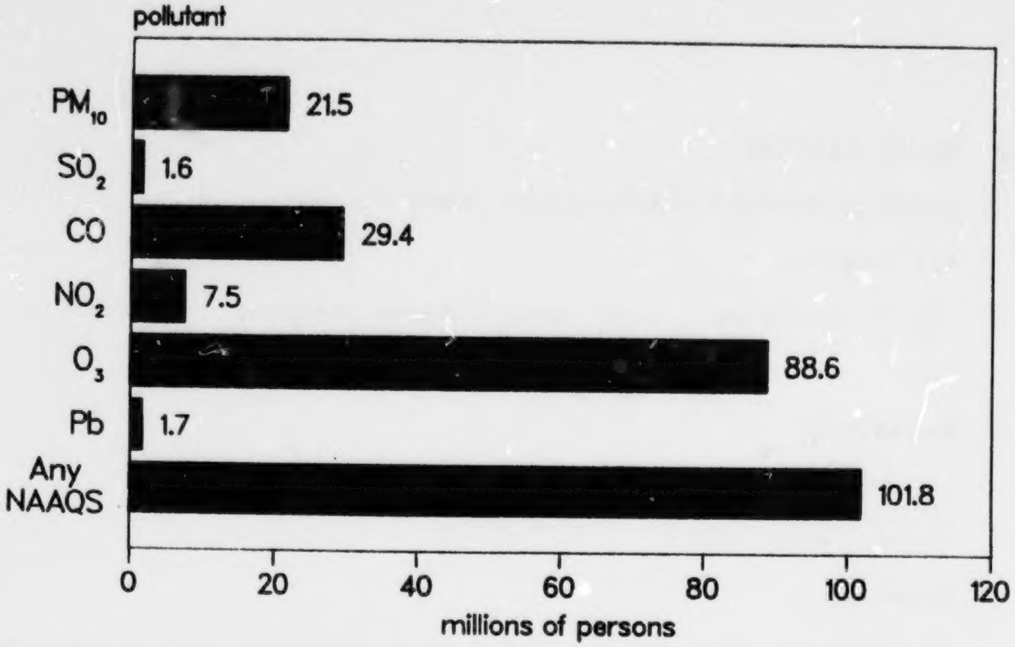


Figure 1-1. Number of persons living in counties with air quality levels above the primary National Ambient Air Quality Standards in 1987 (based on 1980 population data).

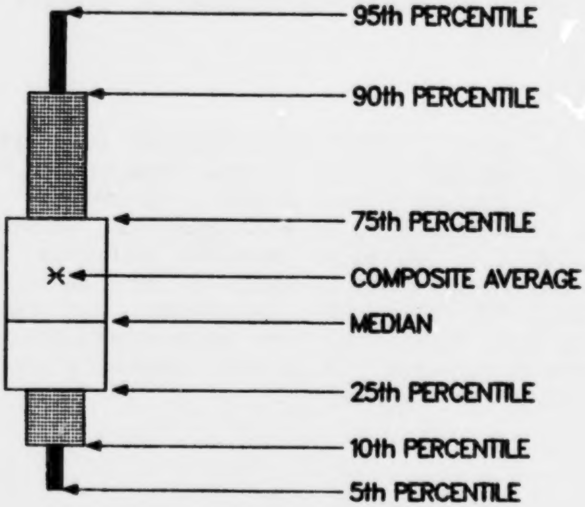

95th PERCENTILE
90th PERCENTILE
75th PERCENTILE
COMPOSITE AVERAGE
MEDIAN
25th PERCENTILE
10th PERCENTILE
5th PERCENTILE

Figure 1-2. Illustration of plotting conventions for boxplots.

1.2 MAJOR FINDINGS

TOTAL SUSPENDED PARTICULATE (TSP)

Air Quality

1978-87: geometric mean: 21 percent decrease (1726 sites) (Figure 1-3)
1983-87: geometric mean: less than 1 percent decrease (1441 sites)
1986-87: geometric mean: 2 percent increase (1441 sites)

Emissions

1978-87: 23 percent decrease (Figure 1-4)
1983-87: 1 percent decrease
1986-87: 3 percent increase

Comments

The 1979-81 data were affected by a change in the filters used to collect TSP, so the decrease between 1981 and 1982 was probably less abrupt than shown in Figure 1-3.

Recent TSP trends have been very flat, with slight changes such as the 1984-85 decrease and the 1986-87 increase likely due to changes in meteorological conditions such as precipitation. The increase in particulate emissions from 1986 to 1987 results from increased forest fire activity in 1987.

Worth Noting

On July 1, 1987, EPA promulgated new standards for particulate matter using a new indicator, PM_{10}, rather than TSP. PM_{10} focuses on those particles with aerodynamic diameters smaller than 10 micrometers, which are likely to be responsible for adverse health effects because of their ability to reach the thoracic or lower regions of the respiratory tract. PM_{10} networks are now being deployed nationally but do not as yet have sufficient historical data for trends analysis. However, summary statistics for 1987 are presented in Section 4.

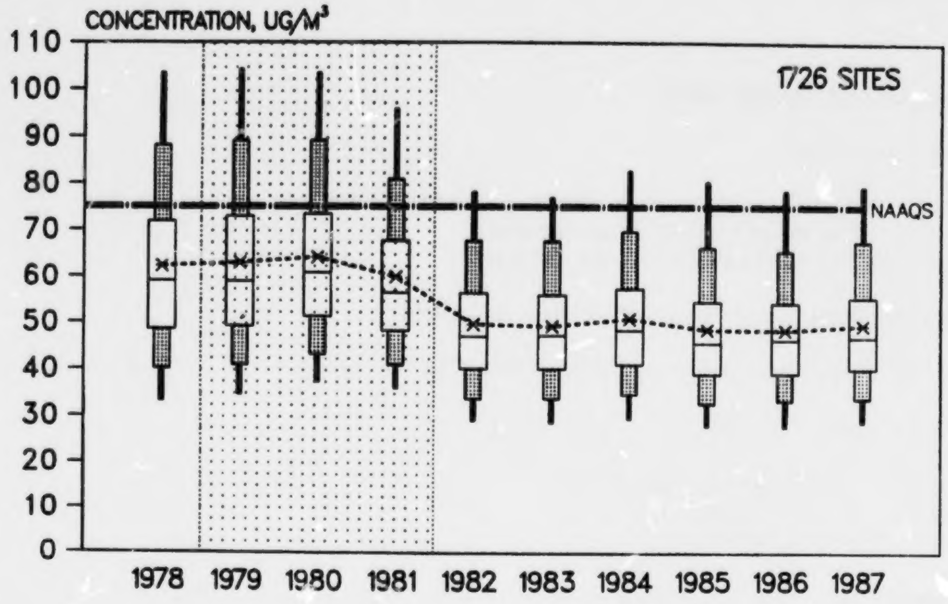


Figure 1-3. Boxplot comparisons of trends in annual geometric mean total suspended particulate concentrations at 1726 sites, 1978-1987.

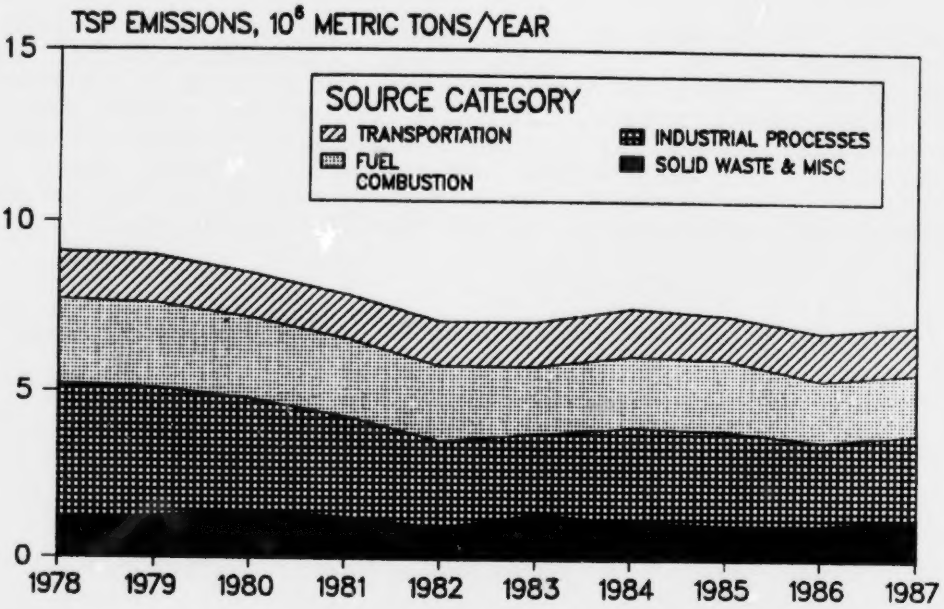


Figure 1-4. National trend in particulate emissions, 1978-1987.

SULFUR DIOXIDE (SO_2)

Air Quality

1978-87: arithmetic mean: 35 percent decrease (347 sites) (Figure 1-5)
24-hour second high: 40 percent decrease
24-hour exceedances: 94 percent decrease

1983-87: arithmetic mean: 10 percent decrease (603 sites)

1986-87: arithmetic mean: 3 percent decrease (603 sites)

Emissions (as SO_x)

1978-87: 17 percent decrease (Figure 1-6)
1983-87: 1 percent decrease
1986-87: 1 percent decrease

Comments

The vast majority of SO_2 monitoring sites do not show any exceedances of the 24-hour NAAQS, hence the exceedance trend is dominated by source oriented sites.

Worth Noting

Ambient SO_2 is well in conformance with the current ambient standards in most U.S. urban areas. Current concerns about ambient SO_2 focus on major emitters which tend to be located in more rural areas. This is the major reason for the disparity between air quality and emission trends for sulfur dioxide. The residential and commercial areas, where most monitors are located, have shown sulfur oxide emission decreases comparable to SO_2 air quality improvement.

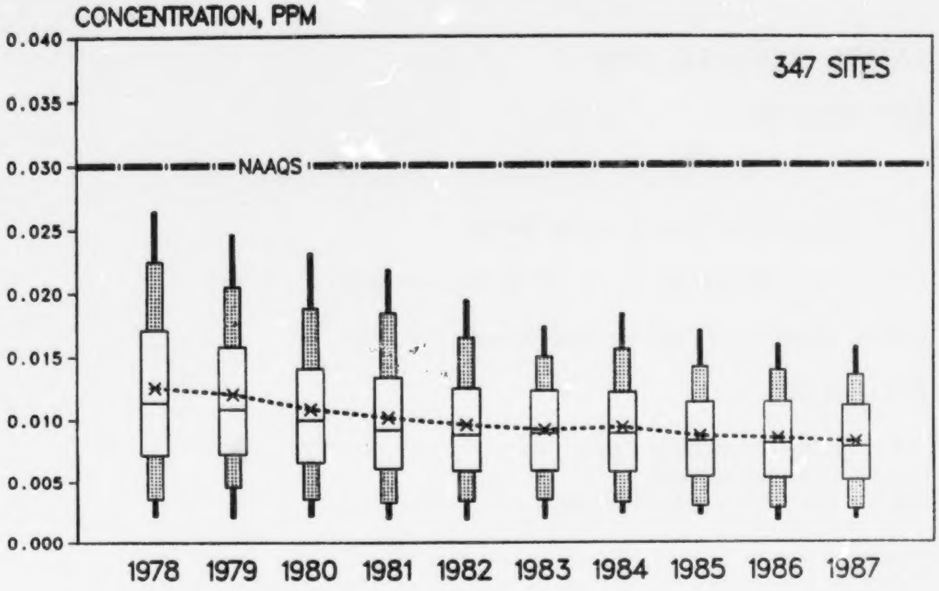


Figure 1-5. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 347 sites, 1978-1987.

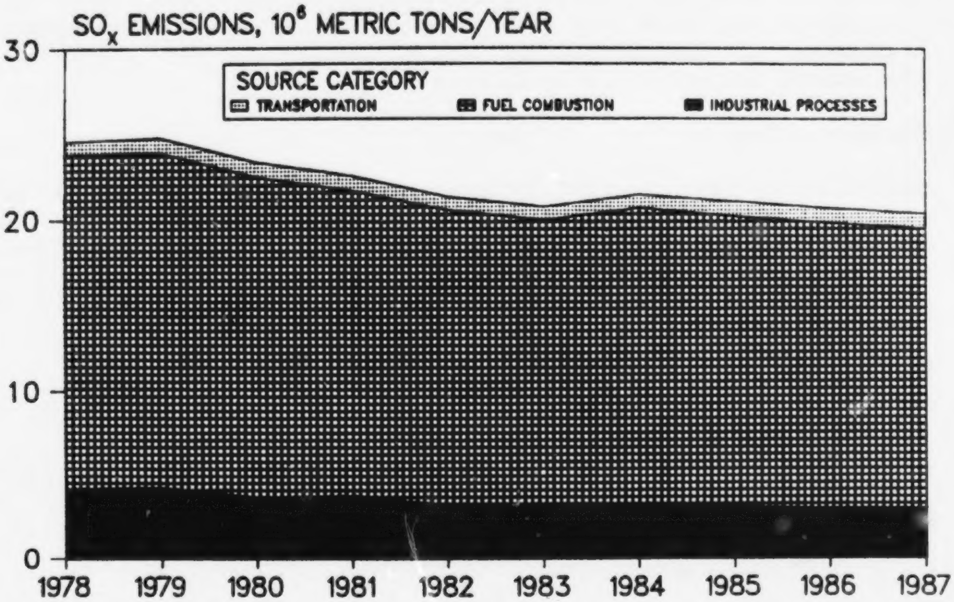


Figure 1-6. National trend in sulfur oxide emissions, 1978-1987.

CARBON MONOXIDE (CO)

Air Quality

1978-87: 8-hour second high: 32 percent decrease (198 sites) (Figure 1-7)

8-hour exceedances: 91 percent decrease

1983-87: 8-hour second high: 16 percent decrease (367 sites)

1986-87: 8-hour second high: 6 percent decrease (367 sites)

Emissions

1978-87: 25 percent decrease (Figure 1-8)
1983-87: 14 percent decrease
1986-87: less than 1 percent increase

Comments

While there is general agreement between the air quality and emission changes over this 10-year period, it should be recognized that the emission changes reflect estimated national totals while the ambient CO monitors are frequently located to identify problems. The mix of vehicles and the change in vehicle miles of travel in an area around a typical CO monitoring site may differ from the national averages. The increase in CO emissions from 1986 to 1987 results from increased forest fire activity in the West.

Worth Noting

The 1978-87 improvement in ambient CO levels, and in estimated national CO emissions, has occurred despite a 24 percent increase in vehicle miles traveled during this 10-year period. In particular, CO emissions from highway vehicles are estimated to have decreased 38 percent in these 10 years because controls have more than offset growth.

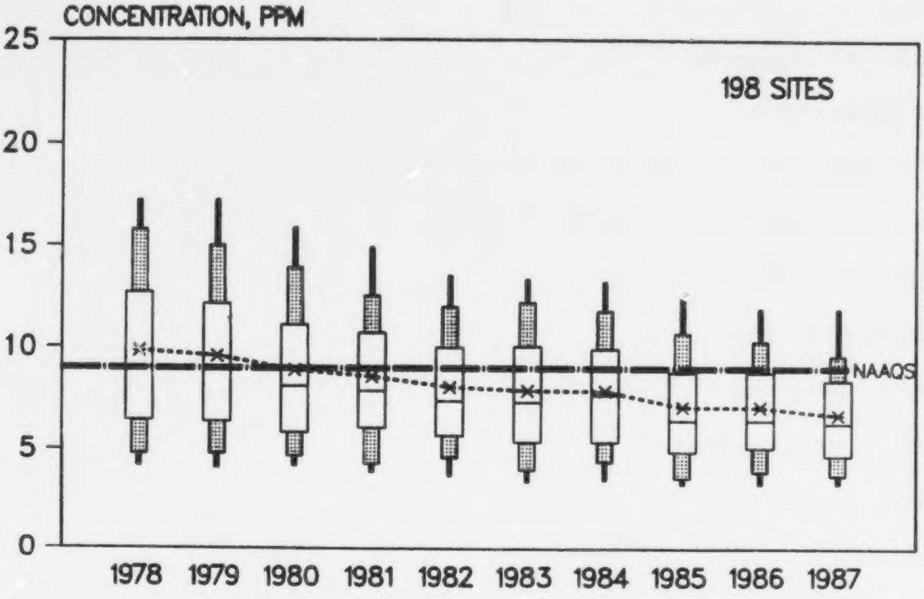


Figure 1-7. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 198 sites, 1978-1987.

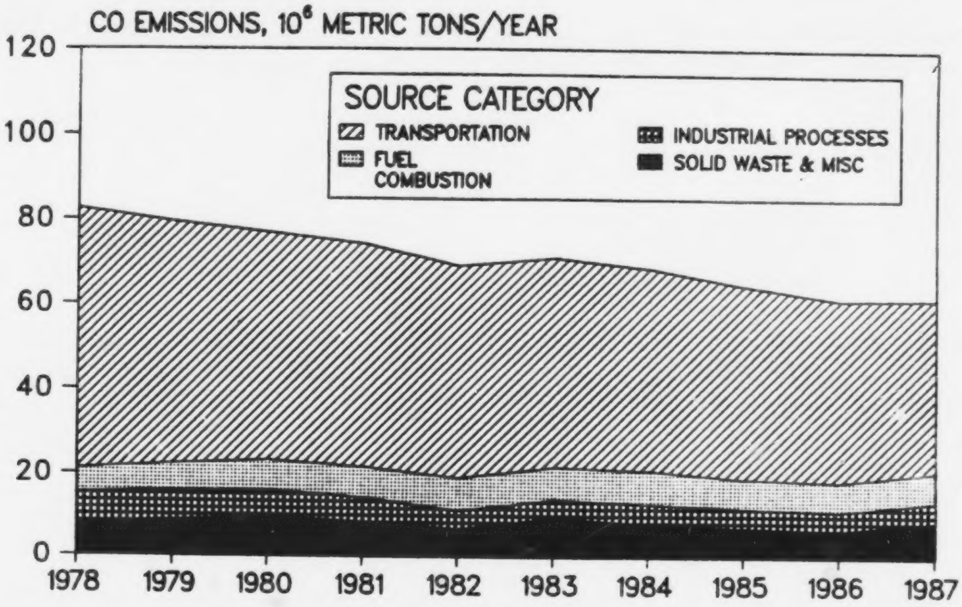


Figure 1-8. National trend in emissions of carbon monoxide, 1978-1987.

NITROGEN DIOXIDE (NO_2)

Air Quality

1978-87: Annual Mean: 12 percent decrease (84 sites) (Figure 1-9)

1983-87: Annual Mean: 2 percent increase (199 sites)

1986-87: Annual Mean: No change (199 sites)

Emissions (NO_x)

1978-87: 8 percent decrease (Figure 1-10)

1983-87: 3 percent increase

1986-87: 1 percent increase

Comments:

The national trend in annual mean NO_2 concentration has been flat during the last 4 years. The increase in emissions from 1983 to 1984 and from 1986 to 1987 were primarily because of increases in stationary source fuel combustion.

Worth Noting:

Los Angeles County is the only county in the country that currently violates the NO_2 NAAQS.

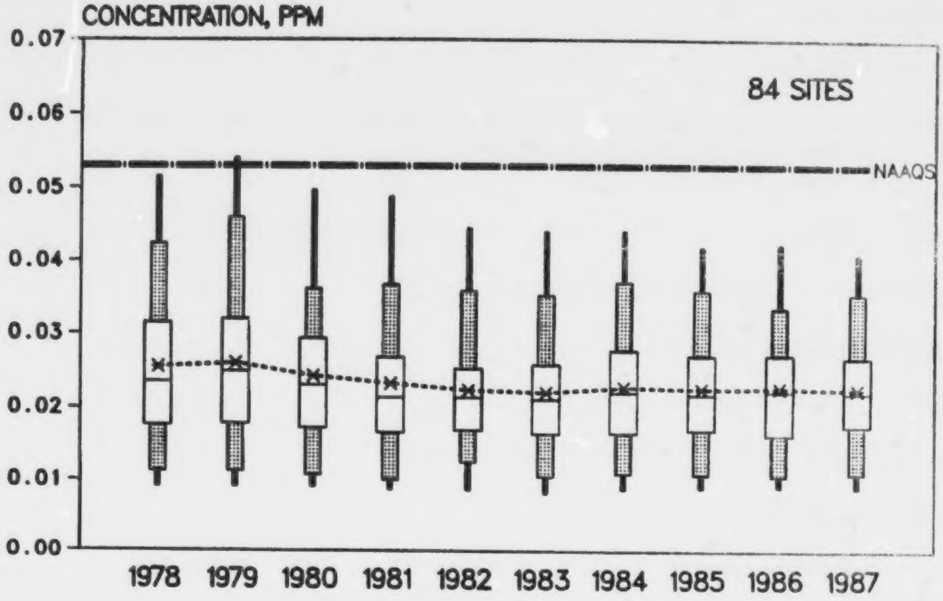


Figure 1-9. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 84 sites, 1978-1987.

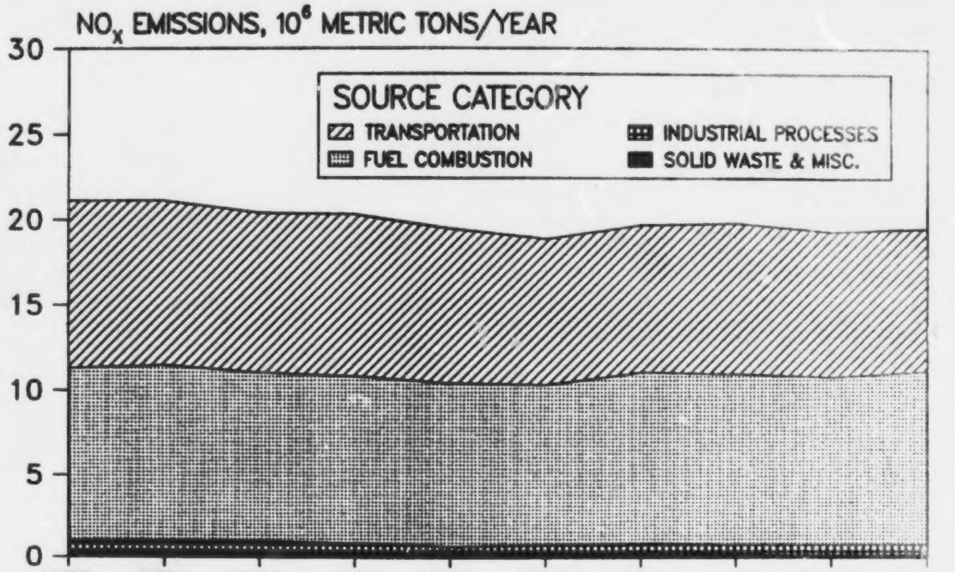


Figure 1-10. National trend in nitrogen oxides emissions, 1978-1987.

OZONE (O_3)

Air Quality

1979-87*: Second Highest Daily Max 1-hour: 9 percent decrease (274 sites) (Figure 1-11)
Exceedance Days: 38 percent decrease
*9-year period (see comments)

1983-87: Second Highest Daily Max 1-hour: 8 percent decrease (522 sites)

1986-87: Second Highest Daily Max 1-hour: 5 percent increase

Emissions (VOC)

1978-87: 17 percent decrease (Figure 1-12)

(NOTE: 9-year 1979-87 decrease was 17 percent)

1983-87: 4 percent decrease

1986-87: 2 percent increase

Comments:

Air quality trends are presented for the 9-year period 1979-87 because ozone data before 1979 are affected by a calibration change. The 10-year period showed a 16 percent improvement in air quality, but this includes the effect of the calibration change, which is difficult to quantify.

Worth Noting:

Ground level ozone is the most pervasive pollutant in urban areas in the U.S. The interpretation of ozone trends is complicated by the impact of meteorological conditions, particularly the summers of 1987 and 1988, which were hotter than 1985 and 1986 in some areas. It is difficult to precisely quantify the impact of these hotter summers and it remains to be seen which weather patterns more likely represent future years.

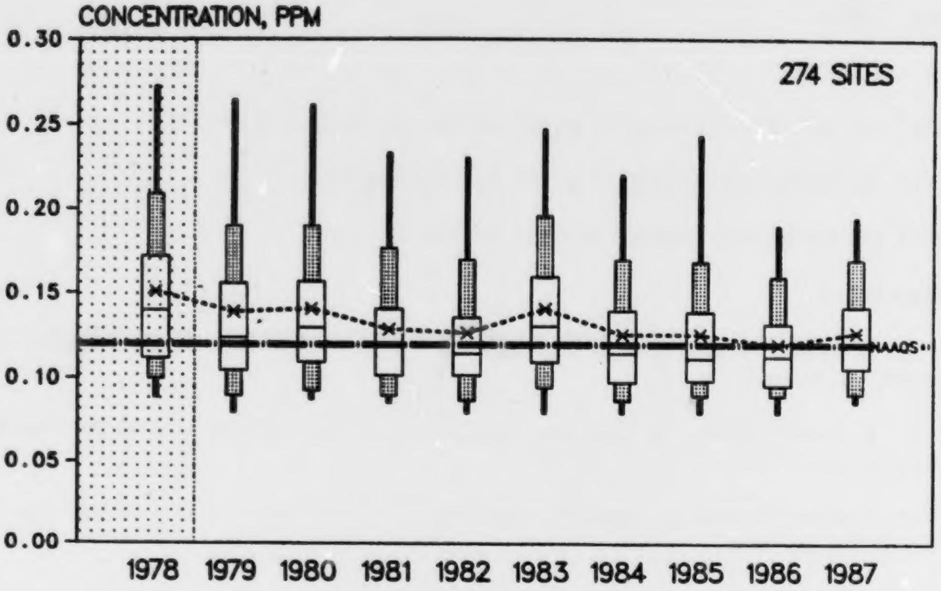


Figure 1-11. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 274 sites, 1978-1987.

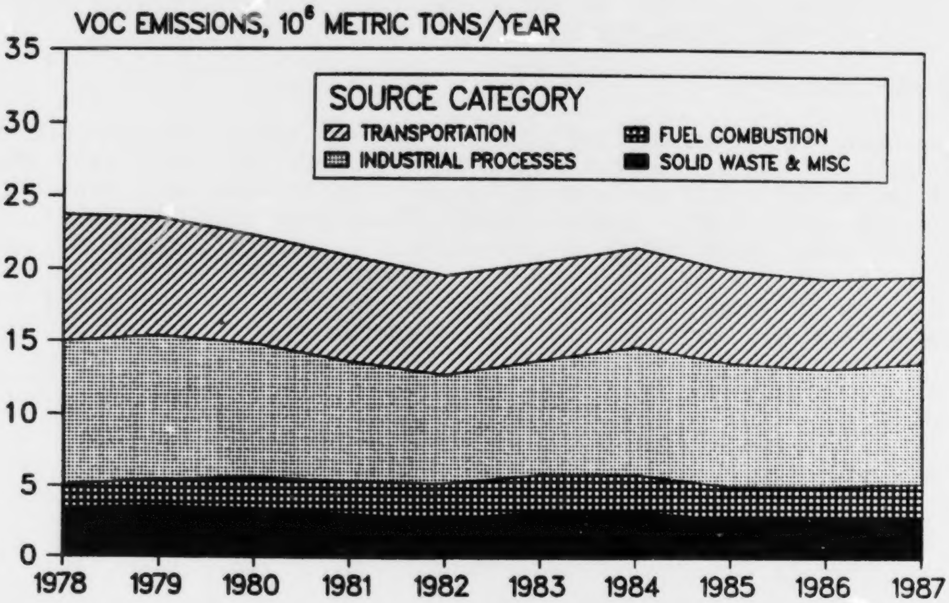


Figure 1-12. National trend in emissions of volatile organic compounds, 1978-1987.

LEAD (Pb)

Air Quality

1978-87: Maximum Quarterly Average: 88 percent decrease (97 sites) (Figure 1-13)

1983-87: Maximum Quarterly Average: 71 percent decrease (394 sites)

1986-87: Maximum Quarterly Average: 19 percent decrease (394 sites)

Emissions

1978-87: 94 percent decrease in total lead emissions - 97 percent decrease in lead emissions from transportation sources.

1983-87: 83 percent decrease in total lead emissions - 93 percent decrease in lead emissions from transportation sources.

1986-87: 6 percent decrease in total lead emissions - 14 percent decrease in lead emissions from transportation sources.

Comments:

The ambient lead trends presented here represent for the most part general urban conditions predominantly reflecting automotive sources. For the first time, ambient trends are also presented for a small number of lead monitoring sites (24) in the vicinity of point sources of lead such as primary and secondary lead smelters.

Worth Noting:

Ambient lead concentrations in urban areas throughout the country continue to drop because of both the increased usage of unleaded gasoline and the reduction of the lead content in leaded gasoline. Also, lead concentrations at monitoring sites near lead point sources show a dramatic decline, as a result of the general factors noted above, as well as the closing of some of these sources, and the reduction of lead emissions by improved control measures.

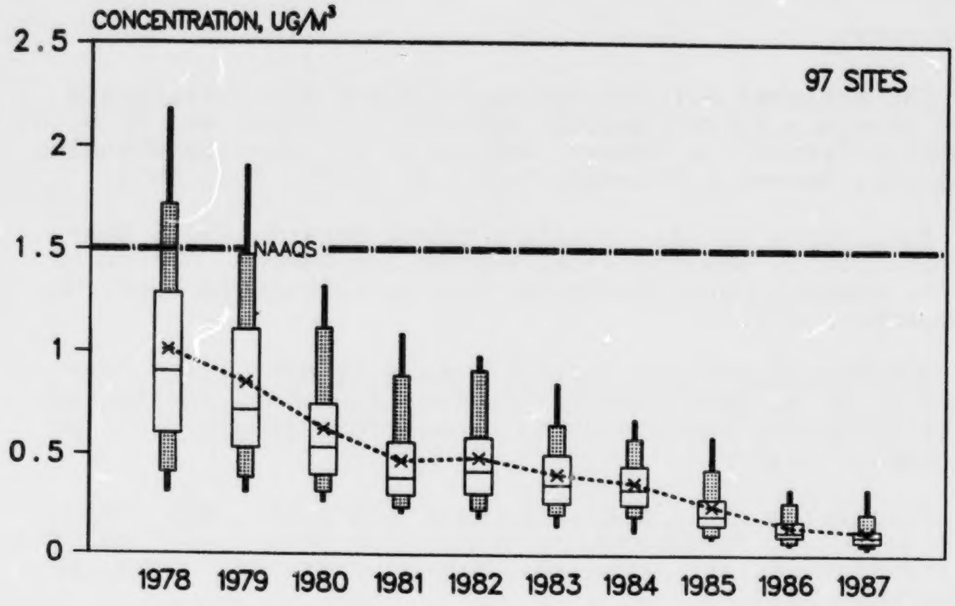


Figure 1-13. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 98 sites, 1978-1987.

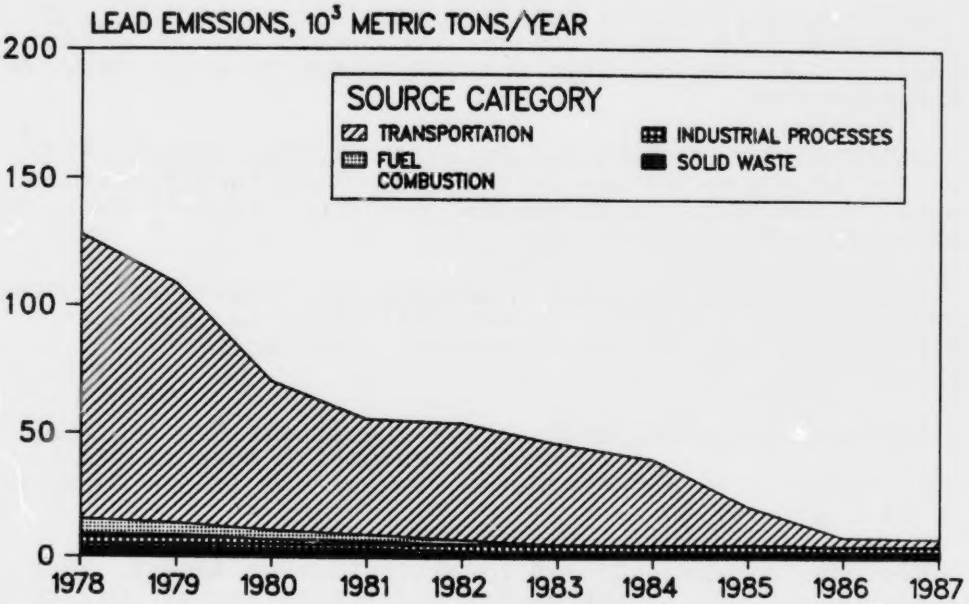


Figure 1-14. National trend in lead emissions, 1978-1987.

1.3 REFERENCES

1. The National Air Monitoring Program: Air Quality and Emissions Trends - Annual Report, EPA-450/1-73-001a and b, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, July 1973.

2. Monitoring and Air Quality Trends Report, 1972, EPA-450/1-73-004, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1973.

3. Monitoring and Air Quality Trends Report, 1973, EPA-450/1-74-007, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, October 1974.

4. Monitoring and Air Quality Trends Report, 1974, EPA-450/1-76-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1976.

5. National Air Quality and Emissions Trends Report, 1975, EPA 450/1-76-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, November 1976.

6. National Air Quality and Emissions Trends Report, 1976, EPA-450/1-77-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1977.

7. National Air Quality and Emissions Trends Report, 1977, EPA-450/2-78-052, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, December 1978.

8. 1980 Ambient Assessment - Air Portion, EPA-450/4-81-014, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1981.

9. National Air Quality and Emissions Trends Report, 1981, EPA-450/4-83-011, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1983.

10. National Air Quality and Emissions Trends Report, 1982, EPA-450/4-84-002, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, March 1984.

11. *National Air Quality and Emissions Trends Report, 1983*, EPA-450/4-84-029, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1985.

12. *National Air Quality and Emissions Trends Report, 1984*, EPA-450/4-86-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1986.

13. *National Air Quality and Emissions Trends Report, 1985*, EPA-450/4-87-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1987.

14. *National Air Quality and Emissions Trends Report, 1986*, EPA-450/4-88-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, February 1988.

2. INTRODUCTION

This report focuses on both 10-year (1978-1987) and 5-year (1983-1987) national air quality trends for each of the major pollutants for which National Ambient Air Quality Standards have been established, as well as Regional and, where appropriate, short-term air quality trends. The national analyses are complemented in Section 5 with air quality trends in selected metropolitan areas for the period 1983 through 1987. The areas examined are Atlanta, GA; Baltimore, MD; Boston, MA; Chicago, IL-Northwestern IN; Denver, CO; Detroit, MI; Houston, TX; Los Angeles-Long Beach, CA; New York, NY-Northeastern NJ; Philadelphia, PA-NJ; Phoenix, AZ; Portland, OR-WA; St. Louis, MO-IL; and Seattle, WA. In both the national 5-year trends and the metropolitan area trends, the shorter time period was used to expand the number of sites available for trend analysis.

The national air quality trends are presented for all sites and for the National Air Monitoring Station (NAMS) sites. The NAMS were established through monitoring regulations promulgated in May 1979[1] to provide accurate and timely data to the U. S. Environmental Protection Agency (EPA) from a national air monitoring network. The NAMS are located in areas with high pollutant concentrations and high population exposure. These stations meet uniform criteria for siting, quality assurance, equivalent analytical methodology, sampling intervals, and instrument selection to assure consistent data reporting among the States. Other sites operated by the State and local air pollution control agencies, such as the State and Local Air Monitoring Stations (SLAMS) and Special Purpose Monitors (SPM), in general, also meet the same rigid criteria, except that in addition to being located in the area of highest concentration and high population exposure, they are located in other areas as well. The ambient levels presented are the results of direct air pollution measurements.

As well as for ambient air quality, trends are also presented for annual nationwide emissions. These are estimates of the amount and kinds of pollution being emitted by automobiles, factories, and other sources, based upon the best available engineering calculations for a given time period. The emission trends are taken from the EPA publication, National Air Pollutant Emission Estimates, 1940-1987[2] and the reader is referred to this publication for more detailed information. Area source fugitive dust emissions (unpaved roads, construction activities, etc.) are not included at all. Similarly, natural sources of particulates, such as wind erosion or dust, are not included. (Forest fires, some of which result from natural causes are included, however). In total, these fugitive emissions may amount to a considerable portion of total particulate emissions. Emission estimates for gasoline-and diesel-powered motor vehicles were based upon vehicle-mile tabulations and upon emission factors from the MOBILE 3.9

TABLE 2-1. National Ambient Air Quality Standards (NAAQS) in Effect in 1987

POLLUTANT	PRIMARY (HEALTH RELATED)		SECONDARY (WELFARE RELATED)	
	AVERAGING TIME	STANDARD LEVEL CONCENTRATION[a]	AVERAGING TIME	CONCENTRATION
TSP[b]	Annual Geometric Mean	75 $\mu g/m^3$		
PM_{10}[c]	Annual Arithmetic Mean	50 $\mu g/m^3$	Same as Primary	
	24-hour	150 $\mu g/m^3$	Same as Primary	
SO_2	Annual Arithmetic Mean	(0.03 ppm) 80 $\mu g/m^3$	3-hour	1300 $\mu g/m^3$ (0.50 ppm)
	24-hour	(0.14 ppm) 365 $\mu g/m^3$		
CO	8-hour	9 ppm (10 $\mu g/m^3$)	No Secondary Standard	
	1-hour	35 ppm (40 $\mu g/m^3$)	No Secondary Standard	
NO_2	Annual Arithmetic Mean	0.053 ppm (100 $\mu g/m^3$)	Same as Primary	
O_3	Maximum Daily 1-hour Average	0.12 ppm[d] (235 $\mu g/m^3$)	Same as Primary	
Pb	Maximum Quarterly Average	1.5 $\mu g/m^3$	Same as Primary	

[a] Parenthetical value is an approximately equivalent concentration.

[b] TSP was the indicator pollutant for the original particulate matter (PM) standards. This standard has been replaced with the new PM_{10} standard and it is no longer in effect.

[c] New PM standards were promulgated in 1987, using PM_{10} (particles less than 10μ in diameter) as the new indicator pollutant. The 24-hour standard is attained when the expected number of days per calendar year above 150 $\mu g/m^3$ is equal to or less than 1, as determined in accordance with Appendix K of the PM NAAQS.

[d] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined in accordance with Appendix H of the Ozone NAAQS.

model. Except for lead emissions, which are reported in gigagrams (one thousand metric tons), the emission data are reported as teragrams (one million metric tons) emitted to the atmosphere per year.[2]

Air quality status may be measured by comparing the ambient air pollution levels with the appropriate primary and secondary National Ambient Air Quality Standards (NAAQS) for each of the pollutants (Table 2-1). Primary standards protect the public health; secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for different averaging times. Long-term standards specify an annual or quarterly mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages. With the exception of the pollutants ozone and PM_{10}, the short-term standards are not to be exceeded more than once per year. The ozone standard requires that the expected number of days per calendar year with daily maximum hourly concentrations exceeding 0.12 parts per million (ppm) be less than or equal to one. The new 24-hour PM_{10} standard also allows one expected exceedance per year.

Section 4 of this report, "Air Quality Levels in Metropolitan Statistical Areas" provides interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs with monitoring data for 1987.

Finally, two additional analyses of ozone air quality data have been included in this report. The first analysis is an application of a Geographical Information System (GIS) to display the chronology of a large scale regional ozone episode which occurred in June 1987. The second new analysis presents a preview of 1988 ozone trends. In response to indications of high ozone levels in early Summer 1988, EPA implemented a cooperative program with the state and local air pollution agencies for the accelerated reporting of preliminary ozone data from a subset of peak monitoring sites. These data have been merged with the trends data base to provide a preliminary assessment of 1988 ozone trends.

2.1 DATA BASE

The ambient air quality data used in this report were obtained from EPA's Aerometric Information and Retrieval System (AIRS). Air quality data are submitted to AIRS by both State and local governments, as well as federal agencies. At the present time, there are about 500 million air pollution measurements on AIRS, the vast majority of which represent the more heavily populated urban areas of the nation.

Previously[3], the size of the available air quality trends data base was expanded by merging data at sites which had experienced changes in the agency operating the site, the instruments used, or in the project codes, such as a change from population oriented to special purpose monitoring. In contrast to the old Storage and Retrieval of Aerometric Data (SAROAD) System, which created separate records in these cases, the pollutant occurrence code (POC) was established in AIRS to create combined summary records for these monitoring situations. However, in the case of SO_2 and Pb, the previous procedure of merging data was employed since the POCs have not yet been resolved on the new data system for many of the sites experiencing such changes.

In order for a monitoring site to have been included in the national 10-year trend analysis, the site had to contain data for at least 8 of the 10 years 1978 to 1987. For the national 5-year trend and metropolitan area analyses, the site had to contain 4 out of 5 years of data to be included as a trend site. Data for each year had to satisfy annual data completeness criteria appropriate to pollutant and measurement methodology. The air quality data are divided into two major groupings -- 24-hour measurements and continuous 1-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and are typically operated on a systematic sampling schedule of once every 6 days, or 61 samples per year. Such instruments are used to measure TSP, SO_2, NO_2 and Pb. Bubbler data were not used in the SO_2 and NO_2 trends analyses because these methods have essentially been phased out of the monitoring network. Total suspended particulate data were judged adequate for trends if there were at least 30 samples for the year. Both 24-hour and composite data were used in the Pb trends analyses. The 24-hour Pb data had to have at least six samples per quarter in at least 3 of the 4 calendar quarters. Monthly composite Pb data were used if at least two monthly samples were available for at least 3 of the 4 calendar quarters.

The 1-hour data are obtained from monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. For continuous hourly data, a valid annual mean for SO_2 and NO_2 trends requires at least 4380 hourly observations. This same annual data completeness, of at least 4380 hourly values, was required for the CO standard related statistics - the second maximum nonoverlapping 8-hour average and the estimated number of exceedances of the 8-hour average CO standard. A slightly different criterion was used for the SO_2 standard related daily statistics - the second daily maximum 24-hour average and the estimated number of daily exceedances of the SO_2 standard. Instead of requiring 4380 or more hourly values, 183 or more daily values were required. A valid day is defined as one consisting of at least 18 hourly observations.

Finally, because of the seasonal nature of ozone, both the second daily maximum 1-hour value and the estimated number of exceedances of the O_3 NAAQS were calculated for the ozone season, which varies by state.[4] For example, in California, the ozone season is defined as 12 months, January through December, while in New Jersey it is defined as 7 months, April through October. In order for a site to be included, at least 50 percent of its daily data had to be from the ozone season. For all pollutants, the site must satisfy the annual completeness criteria, specified above in at least 8 out of 10 years for it to be included in the 10-year air quality trends data base, and 4 out of 5 years to be included in both the 5-year trend and metropolitan area trend data bases. Table 2-2 displays the number of sites meeting the completeness criteria for both trends data bases. The shorter time period was used in the metropolitan area analyses to expand the number of sites available for trend analyses.

The use of moving 10-year and 5-year windows for trends yields a data base that is more consistent with the current monitoring network. In addition, this procedure increased the total number of trend sites by 16 percent for the 10-year period, but decreased by 14 percent for the 5-year period relative to the data bases used in the last annual report.[3] The size of the TSP monitoring network has declined during the past 2 years because of promulgation of the PM_{10} standard. This decline in the number of TSP sites between the 10-year and 5-year data bases results from the difference in the number of years required for the two time periods. If a site discontinued operation in 1986, it would be included in the 10-year data base, but not in the 5-year data base (since 2 of the 5 years would be missing). The trend from 1983 on reflects the period following the implementation of the monitoring regulations.[1] The regulations required uniform siting of monitors and placed greater emphasis on quality assurance. In general, the data from the post 1980 period should be of the highest quality. As would be expected, there are considerably more trend sites for the 5-year period than for the 10-year period - 3526 total trend sites versus 2726 trends sites, respectively (Table 2-2). This 29 percent increase in the number of trends sites for the 5-year period over the 10-year period reflects the greater utilization of ambient air quality data that is achieved by examining the shorter time period. Focusing on the non-TSP sites, there is a 108% increase in the number of sites in the 5-year data base as compared to the 10-year period. Except for NO_2, trend sites can be found in all EPA Regions (Figure 2-1) for TSP, SO_2, CO, O_3 and Pb for the 5-year period.

2.2 TREND STATISTICS

The air quality analyses presented in this report comply with the recommendations of the Intra-Agency Task Force on Air Quality

Indicators.[5] This task force was established in January 1980 to recommend standardized air quality indicators and statistical methodologies for presenting air quality status and trends. The Task Force report was published in February 1981. The air quality statistics used in these pollutant- specific trend analyses relate to the appropriate NAAQSs. Two types of standard-related statistics are used - peak statistics (the second maximum 24-hour SO_2 average, the second maximum nonoverlapping 8-hour CO average, and the second daily maximum 1-hour O_3 average) and long-term averages (the annual geometric mean for TSP, the annual arithmetic means for SO_2 and NO_2, and the quarterly arithmetic mean for Pb). In the case of the peak statistics, the second maximum value is used, because this is the value which traditionally has been used to determine whether or not a site has or has not violated an air quality standard in a particular year. A composite average of each of these statistics is used in the graphical presentations which follow. In all cases, all sites were weighted equally in calculating the composite average trend statistic.

In addition to the standard related statistics, other statistics are used, when appropriate, to provide further clarification of observed air quality trends. Particular attention is given to the estimated number of exceedances of the short-term NAAQSs. The estimated number of exceedances is the measured number of exceedances adjusted to account for incomplete sampling.

For a pollutant such as ozone, for which the level of the standard was revised in 1979, exceedances for all years were computed using the most recent level of the standard. This was done to ensure that the trend in exceedances is indicative of air quality trends rather than of a change in the level of the standard.

Table 2-2. Comparison of Number of Sites for 10-Year and 5-Year Air Quality Trends

POLLUTANT	NUMBER OF SITES 1978-87 TREND	NUMBER OF SITES 1983-87 TREND	% CHANGE IN THE NO. OF TREND SITES 1978-87 VS. 1983-87
Total Suspended Particulate (TSP)	1726	1441	-17%
Sulfur Dioxide (SO_2)	347	603	+74%
Carbon Monoxide (CO)	198	367	+85%
Nitrogen Dioxide (NO_2)	84	199	+137%
Ozone (O_3)	274	522	+91%
Lead (Pb)	97	394	+304%
Total	2726	3526	+29%

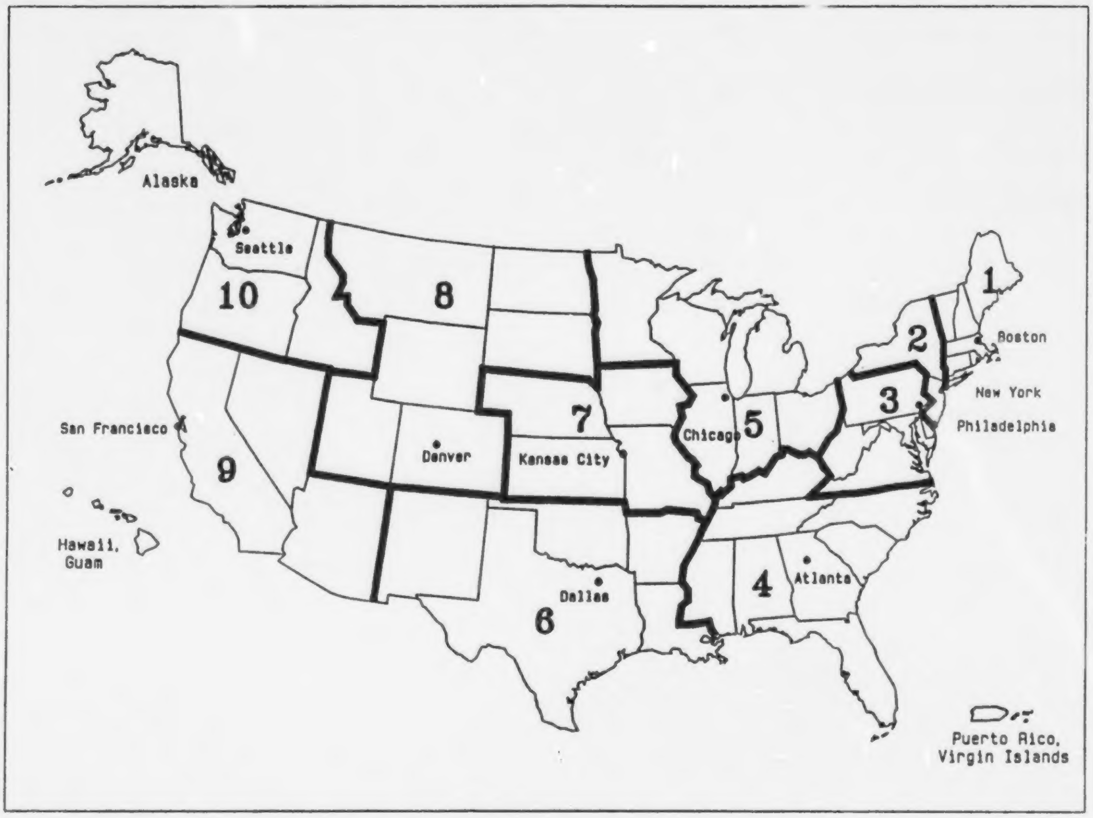

Alaska
Seattle
10
8
1
2
Boston
New York
3
Philadelphia
San Francisco
9
Denver
7
Kansas City
Chicago
5
Hawaii, Guam
Dallas
6
4
Atlanta
Puerto Rico, Virgin Islands

Figure 2-1. Ten Regions of the U.S. Environmental Protection Agency.

2.3 REFERENCES

1. Ambient Air Quality Surveillance, 44 FR 27558, May 10, 1979.

2. National Air Pollutant Emission Estimates, 1940-1987, EPA-450/4-88-022, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January, 1989.

3. National Air Quality and Emissions Trends Report, 1986, EPA-450/4-88-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1988.

4. Ambient Air Quality Surveillance, 51 FR 9597, March 19, 1986.

5. U.S. Environmental Protection Agency Intra-Agency Task Force Report on Air Quality Indicators, EPA-450/4-81-015, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1981.

3. NATIONAL AND REGIONAL TRENDS IN NAAQS POLLUTANTS

This chapter focuses on both 10-year (1978-1987) and recent 5-year (1983-1987) trends for each of the six major pollutants, as well as short term air quality trends. Comparisons are made between all the trend sites and the NAMS subset. Trends are examined for both the nation and the ten EPA Regions.

The air quality trends information is presented using trend lines, confidence intervals, boxplots[1] and bar graphs. This report presents statistical confidence intervals to facilitate a better understanding of measured changes in air quality. Confidence intervals are placed around composite averages, which are based on sites that satisfy annual data completeness requirements. The confidence intervals can be used to make comparisons between years; if the confidence intervals for any 2 years do not overlap, then the composite averages of the 2 years are significantly different (Figure 3-1). Ninety-five percent confidence intervals for composite averages of annual means (arithmetic and geometric) and second maxima were calculated from a two-way analysis of variance followed by an application of the Tukey Studentized Range.[2] The confidence intervals for composite averages of estimated exceedances were calculated by fitting Poisson distributions[3] to the exceedances each year and then applying the Bonferroni multiple comparisons procedure.[4] The utilization of these procedures is explained in publications by Pollack, Hunt and Curran[5] and Pollack and Hunt.[6]

The boxplots have the advantage of displaying, simultaneously, several features of the data. Figure 3-2 illustrates the use of this technique in presenting the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average. The 5th, 10th and 25th percentiles depict the "cleaner" sites. The 75th, 90th and 95th depict the "higher" sites, and the median and average describe the "typical" sites. For example, 90 percent of the sites would have concentrations equal to or lower than the 90th percentile. Although the average and median both characterize typical behavior, the median has the advantage of not being affected by a few extremely high observations. The use of the boxplots allows us simultaneously to compare trends in the "cleaner", "typical" and "higher" sites.

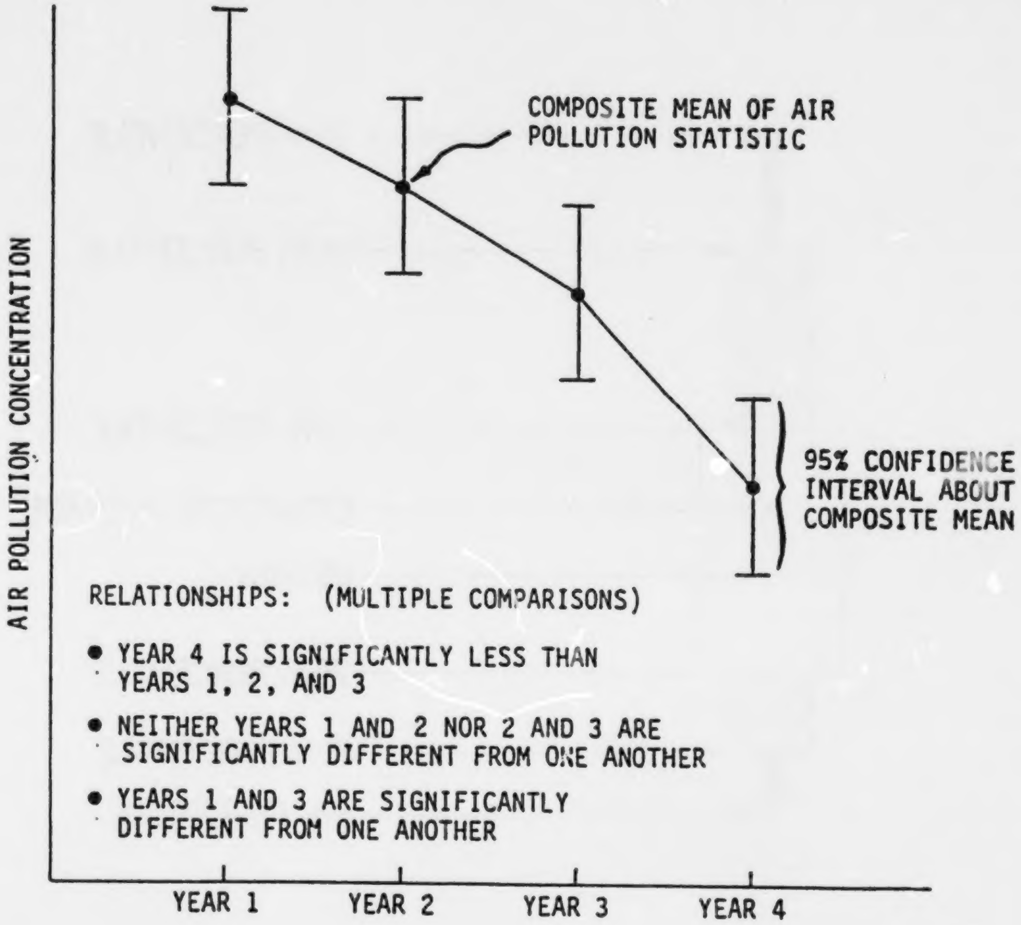
Boxplots of all trend sites are presented for each year in the 10-year trend. In the recent 5-year trend, the boxplots are presented for the years 1983 through 1987. The recent 5-year trend was introduced in the 1984 report[7] to increase the number of sites available for analysis and to make use of data from more recently established sites. The recent 5-year period is presented to take advantage of the larger number of sites and of the fact that the data from this period should be of the highest quality, with sites meeting uniform siting criteria and high standards of quality assurance.

Bar graphs are used for the Regional comparisons with the 5-year trend data base. The composite averages of the appropriate air quality statistic of the years 1985, 1986 and 1987 are presented. The approach is simple, and it allows the reader at a glance to compare the short-term trends in all ten EPA Regions.

In addition to concentration related statistics, other statistics are used, when appropriate, to clarify further the observed air quality trends. Particular attention is given to the estimated number of exceedances of the short-term NAAQSs. The estimated number of exceedances is the measured number of exceedances adjusted to account for incomplete sampling. Trends in exceedances tend to be more variable than in the other concentration related statistics, particularly on a percentage basis. For example, a site may show a 50 percent decrease in annual exceedances, from 2 to 1 per year, and yet record less than a 5 percent decrease in average concentration levels. The change in concentration levels is likely to be more indicative of changes in emission levels.

Trends are also presented for annual nationwide emissions. These emissions data are estimated using the best available engineering calculations. The emissions data are reported as teragrams (one million metric tons) emitted to the atmosphere per year, with the exception of lead emissions, which are reported as gigagrams (one thousand metric tons).[8] These are estimates of the amount and kinds of pollution being generated by automobiles, factories and other sources. Estimates for earlier years are recomputed using current methodology so that these estimates are comparable over time.

Finally, two additional analyses of ozone air quality data have been included in this report. The first analysis is an application of a Geographical Information System (GIS) to display the chronology of a large scale regional ozone episode which occurred in June 1987. The second analysis presents a preview of 1988 ozone trends based on preliminary 1988 ozone data from a subset of peak monitoring sites.



RELATIONSHIPS: (MULTIPLE COMPARISONS)

- YEAR 4 IS SIGNIFICANTLY LESS THAN YEARS 1, 2, AND 3
- NEITHER YEARS 1 AND 2 NOR 2 AND 3 ARE SIGNIFICANTLY DIFFERENT FROM ONE ANOTHER
- YEARS 1 AND 3 ARE SIGNIFICANTLY DIFFERENT FROM ONE ANOTHER

Figure 3-1. **Sample illustration of use of confidence intervals to determine statistically significant change.**

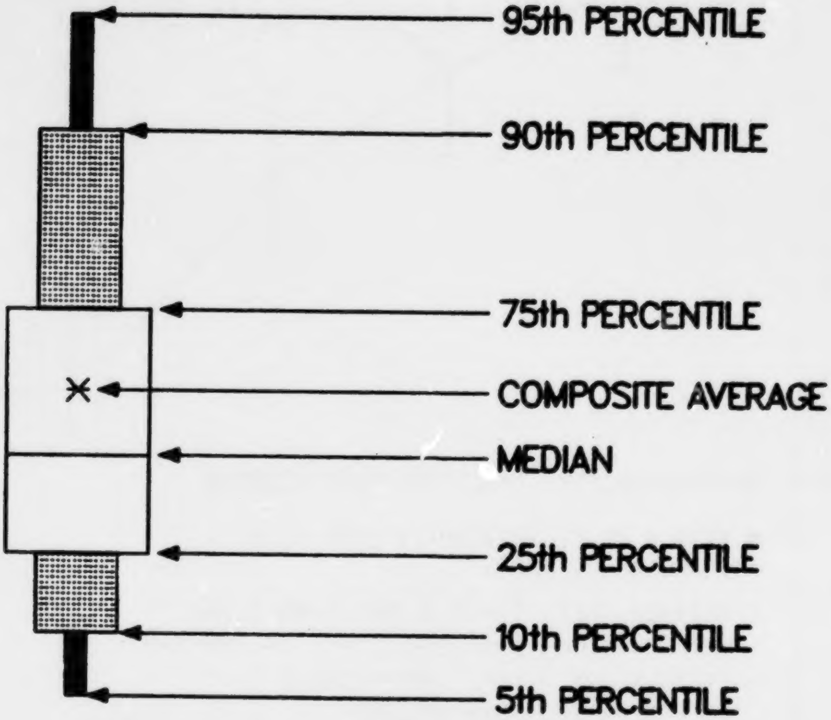

95th PERCENTILE
90th PERCENTILE
75th PERCENTILE
COMPOSITE AVERAGE
MEDIAN
25th PERCENTILE
10th PERCENTILE
5th PERCENTILE

Figure 3-2. Illustration of plotting conventions for boxplots.

3.1 TRENDS IN TOTAL SUSPENDED PARTICULATE

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust as well as particles formed in the atmosphere by transformation of emitted gases such as sulfur dioxide and volatile organic compounds.

Total suspended particulate (TSP) was the indicator of suspended particles in the ambient air prior to the promulgation of the new particulate matter standards. TSP is measured using a high volume sampler (Hi-Vol) which collects suspended particles ranging up to approximately 45 micrometers in diameter. Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were set in 1971, with TSP as the indicator pollutant.

On July 1, 1987, EPA promulgated new annual and 24-hour standards for particulate matter, using a new indicator, PM_{10}, that includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most adverse health effects of particulate because of their ability to reach the thoracic or lower regions of the respiratory tract. The original (TSP) standards were an annual geometric mean of 75 $\mu g/m^3$, not to be exceeded, and a 24-hour concentration of 260 $\mu g/m^3$, not to be exceeded more than once per year. The new (PM_{10}) standards specify an expected annual arithmetic mean not to exceed 50 $\mu g/m^3$ and an expected number of 24-hour concentrations greater than 150 $\mu g/m^3$ per year not to exceed one.

Now that the standards have been revised, PM_{10} monitoring networks are being deployed nationally. Figure 3-3 depicts the geographic coverage of the State and Local Air Monitoring Networks (SLAMS). Unfortunately, the PM_{10} SLAMS do not yet provide sufficient information on which to base meaningful trends. Therefore, the particulate matter trends presented in this section will continue to be based on TSP. The annual geometric mean for TSP is a more stable indicator of air quality than the observed 24-hour peak values, and will be used as the trend statistic. When sufficient information is available on PM_{10} air quality trends, future reports will present analyses based on the new particulate matter indicator.

3.1.1 Long-term TSP Trends: 1978-87

The 10-year trend in average TSP levels, 1978 through 1987, is shown in Figure 3-4 for 1726 sites geographically distributed throughout the Nation and is presented for historical perspective. Trends are also shown for the subset of 431 National Air Monitoring

Stations (NAMS) which are located in areas of greater than 50,000 in population. The TSP levels are expressed in terms of the composite average annual geometric mean.

The curves in Figure 3-4 show identical trends for both the NAMS and the larger group of sites, although composite particulate concentrations are higher for the NAMS. For both curves, composite TSP concentrations are high and relatively stable in the 1978-1980 period and are lower and relatively stable in the 1982-1987 period. A large decrease is apparent in the intervening years, particularly from 1981 to 1982. As previously reported, EPA has determined that the measurements produced during the years 1979, 1980 and 1981 may be biased high due to the type of filters used to collect the TSP.[9] For this reason, the portion of Figure 3-4 corresponding to the years 1979-1981 are stippled, to indicate the uncertainty in the TSP measurements collected during this period. Although the difference between 1978 and post-1981 is real, the pattern of the yearly change in TSP between 1978 and 1981 is difficult to assess and most of the large apparent decrease in pollutant concentrations between 1981 and 1982 can be attributed to a change in these filters.[9-12]

The composite average of TSP levels measured at 1726 sites, distributed throughout the Nation, decreased 21 percent during the 1978 to 1987 time period, and the subset of 431 NAMS decreased 22 percent. Figure 3-4 also includes 95 percent confidence intervals developed for the composite annual estimates. It can be seen that the estimates for 1982 - 1987 are all significantly lower than those of 1978. Also, 1985 and 1986 are statistically indistinguishable, and indicate the lowest particulate levels in the 10-year period. These recent trends in particulate matter will be discussed in more detail in Section 3.1.2.

The long-term trends in TSP are also illustrated in Figure 3-5. Using the same national data base of 1726 TSP sites, Figure 3-5 shows the yearly change in the entire national concentration distribution using boxplot displays. A decrease occurred at every percentile level between 1978 and 1987, further indicating a broad national improvement in ambient particulate concentrations throughout the country.

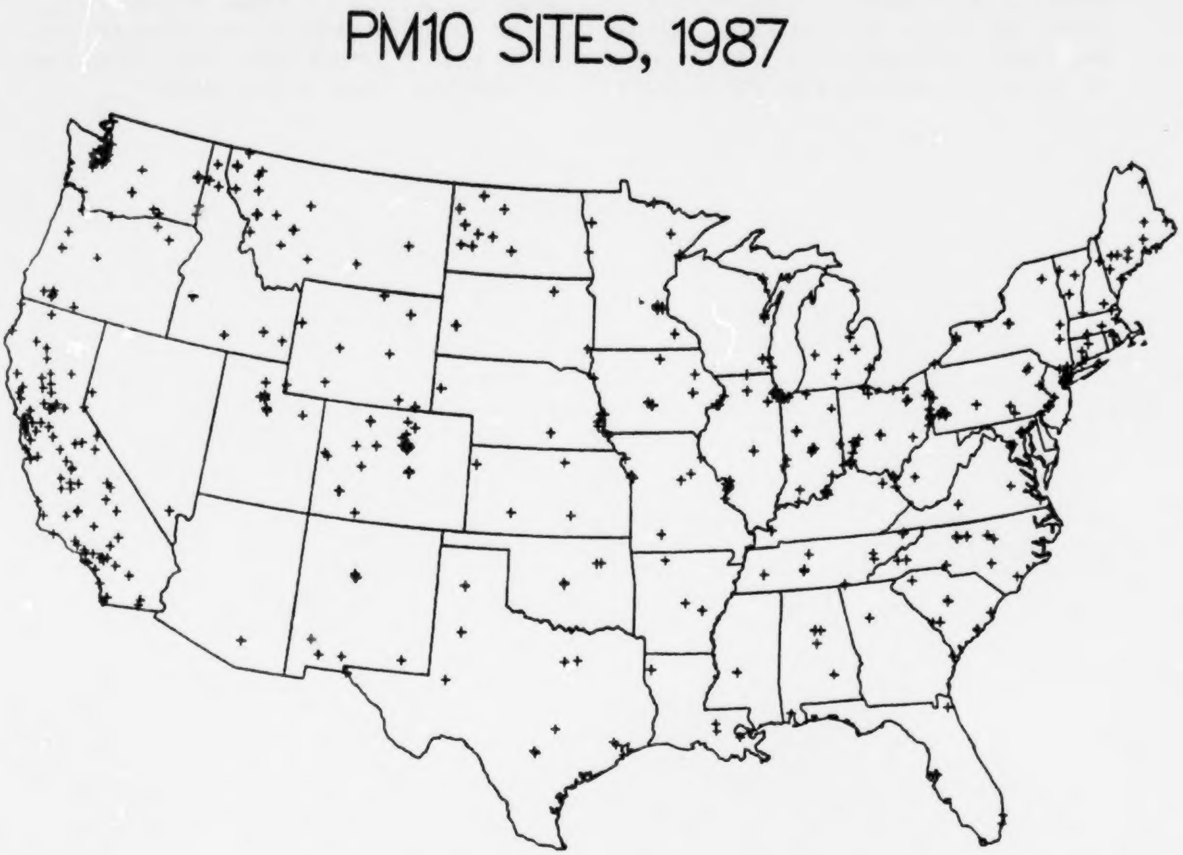

PM10 SITES, 1987

Figure 3-3. Status of PM_{10} monitoring network, 1987.

Nationwide TSP emission trends show an overall decrease of 23 percent from 1978 to 1987 which coincidentally matches the TSP air quality improvement. (See Table 3-1 and Figure 3-6). The trend in PM emissions is normally not expected to agree precisely with the trend in ambient TSP levels due to unaccounted for natural PM background and uninventoried emission sources such as unpaved roads and construction activity. Such fugitive emissions could be of significant magnitude and are not considered in estimates of the annual nationwide total. The 10-year reduction in inventoried particulate emissions occurred primarily because of reductions in industrial processes. This is attributed to installation of control equipment, and also to reduced activity in some industries, such as iron and steel. Other areas of TSP emission reductions include reduced coal burning by non-utility users and installation of control equipment by electric utilities that burn coal.[8]

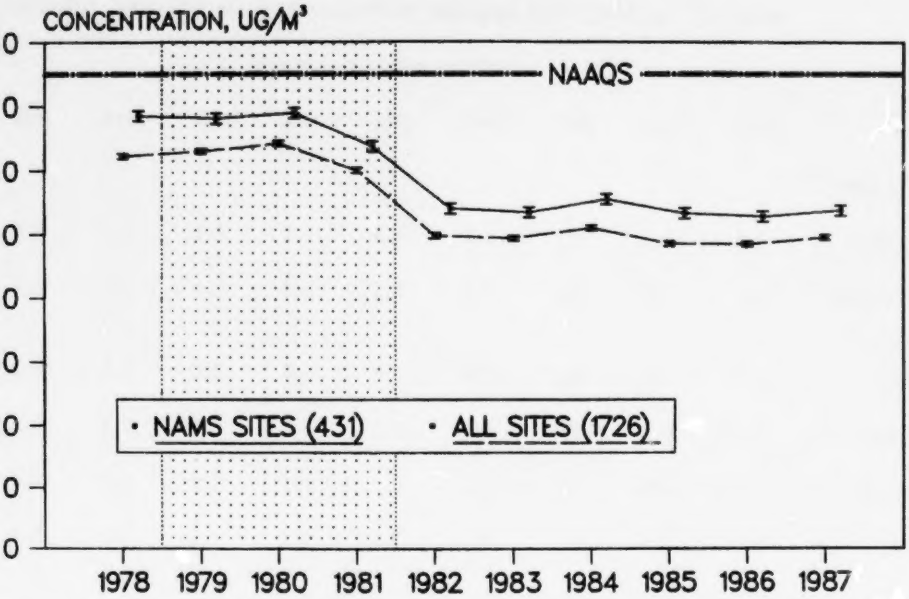


Figure 3-4. National trend in the composite average of the geometric mean total suspended particulate at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

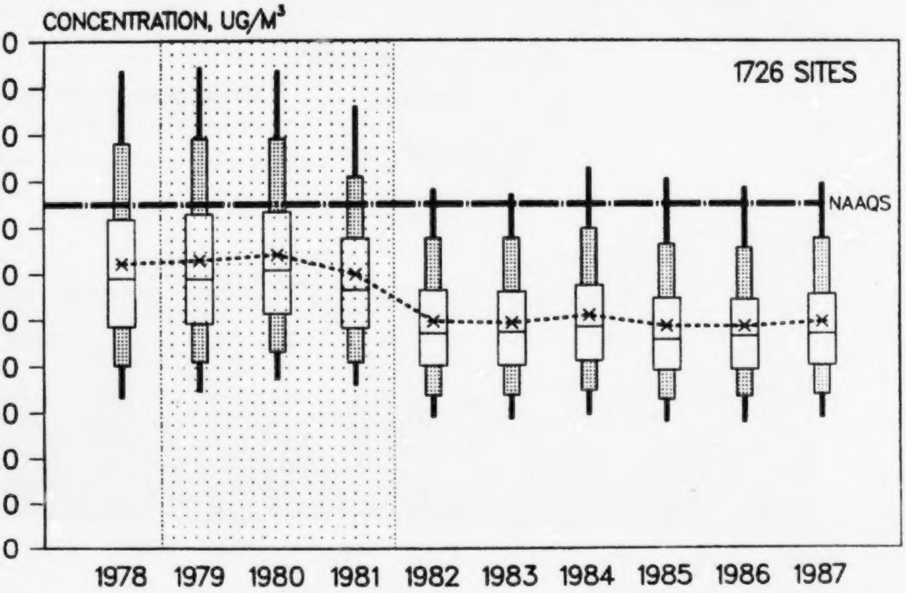


Figure 3-5. Boxplot comparisons of trends in annual geometric mean total suspended particulate concentrations at 1726 sites, 1978-1987.

Table 3-1. National Total Suspended Particulate Emission Estimates, 1978-1987.

(million metric tons/year)

Source Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Transportation	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4
Fuel Combustion	2.5	2.5	2.4	2.3	2.2	2.0	2.1	1.8	1.8	1.8
Industrial Processes	4.0	3.8	3.3	3.0	2.6	2.4	2.8	2.8	2.5	2.5
Solid Waste	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Miscellaneous	0.8	0.9	1.1	0.9	0.7	1.1	0.9	0.8	0.8	1.0
Total	9.1	8.9	8.5	8.0	7.1	7.1	7.4	7.0	6.8	7.0

NOTE: The sums of sub-categories may not equal total due to rounding.

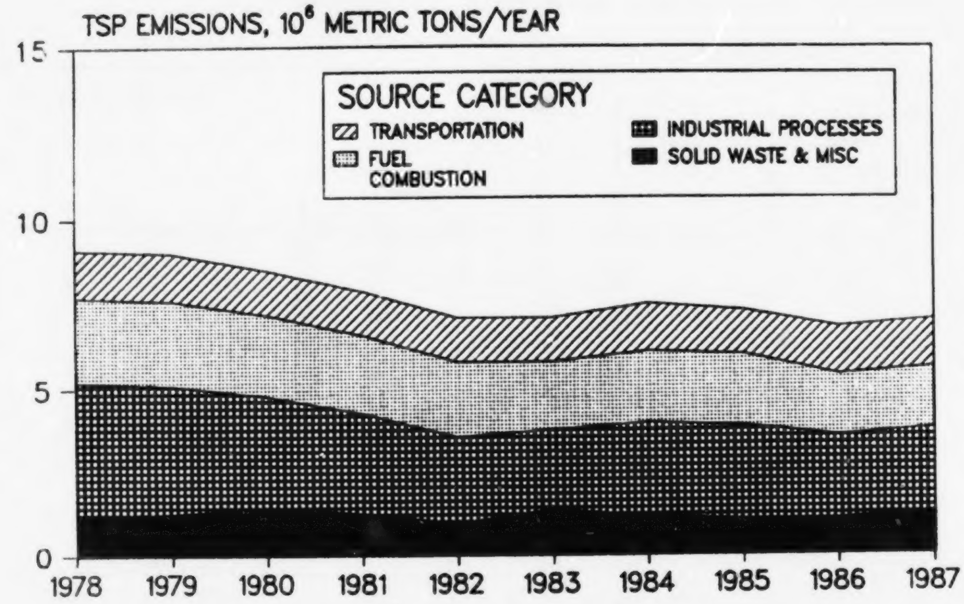


Figure 3-6. National trend in particulate emissions, 1978-1987.

3.1.2 Recent TSP Trends: 1983-87

The trends for the 5-year period, 1983 through 1987 are presented in terms of 1441 sites which produced data in at least 4 of these 5 years. The group of sites qualifying for this analysis is smaller than the group used in previous trends reports, reflecting the revisions to TSP SLAMS networks and the shift of particulate monitoring to PM_{10}. Figure 3-7 presents a boxplot display of the 1983-1987 annual TSP concentration distributions. Very little change in TSP concentrations is evident between 1983 and 1987. As mentioned in Section 3.1.1, generally lower concentrations were measured in 1985 and 1986, and TSP levels in 1984 were generally the highest in the 5-year period. A small 2 percent increase was seen between 1986 and 1987. This pattern in air quality generally matches the 5-year trend in national particulate emission estimates.

Particulate emissions showed little change from 1983 to 1987. They were highest in 1984 because of increases in industrial processes. Emissions were at their lowest in 1986, through subsequent reductions in the industrial sector. Because of an increase in forest fires in 1987, national total emissions returned to their earlier levels. The major fires in Yellowstone during the summer of 1988 could cause these levels to continue to climb. Emissions from forest fires now typically represent 10 to 14 percent of the national total. Since particulate emissions from fires are primarily small particles, future trends report emphasis on PM_{10} may put more attention on fires as an important source of air pollution.

Figure 3-8 focuses on the last 3 years with a bar chart of Regional average TSP. Overall, there were relatively small changes in most Regions. Many Regions had their lowest levels of TSP in 1986 with small increases in 1987.

The observed year-to-year variations in total suspended particulate levels may in part be attributable to meteorology. Among all meteorological parameters, precipitation has been shown to have had the greatest influence on particulate air quality. Rainfall has the effect of reducing reentrainment of particles and of washing particles out of the air. An examination of Regional precipitation patterns shows that the eight Regions with 1986-1987 TSP increases were also the only Regions which experienced decreases in total precipitation, relative to normal.[13] Although these decreases in precipitation were only 5 to 10 percent, they could possibly have contributed to the particulate matter increases in these areas. The generally drier conditions undoubtedly are responsible, in part, for the increase in forest fires which was noted earlier. The largest year-to-year change in particulates occurred in the northwest (Region X), where both 1985 and 1987 were unusually dry and had higher particulates, while 1986 produced normal precipitation and lower average particulate concentrations.

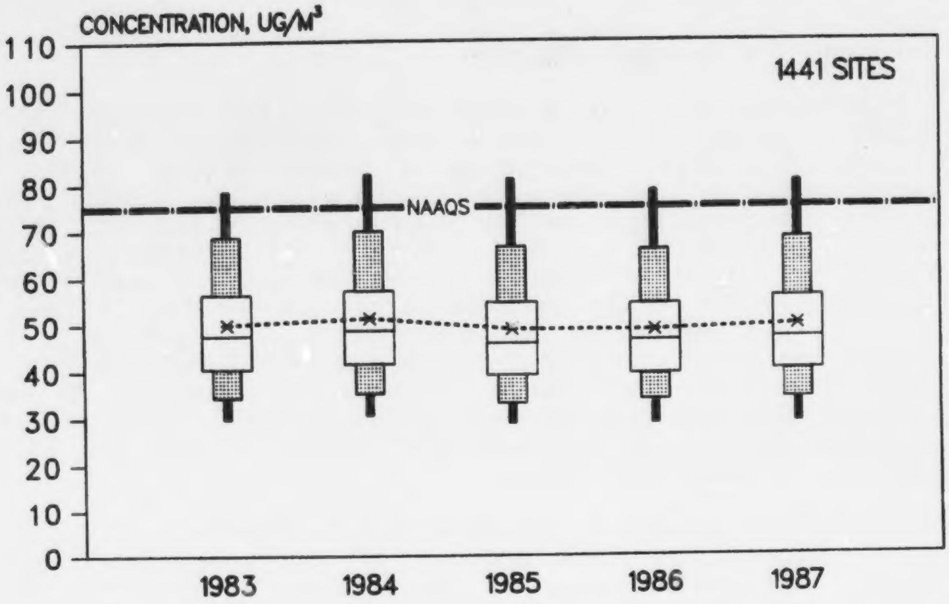


Figure 3-7. Boxplot comparisons of trends in annual mean total suspended particulate concentrations at 1441 sites, 1983-1987.

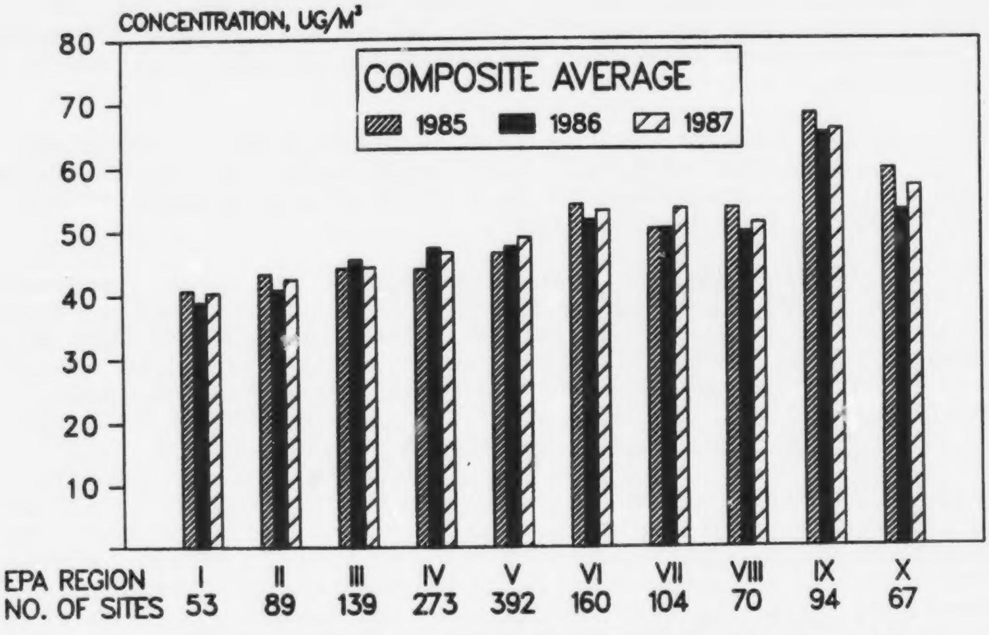


Figure 3-8. Regional comparisons of the 1985, 1986, 1987 composite averages of the geometric mean total suspended particulate concentration.

3.2 TRENDS IN SULFUR DIOXIDE

Ambient sulfur dioxide (SO_2) results largely from stationary source coal and oil combustion and from nonferrous smelters. There are three NAAQS for SO_2: an annual arithmetic mean of 0.03 ppm (80 $\mu g/m^3$), a 24-hour level of 0.14 ppm (365 $\mu g/m^3$) and a 3-hour level of 0.50 ppm (1300 $\mu g/m^3$). The first two standards are primary (health-related) standards, while the 3-hour NAAQS is a secondary (welfare-related) standard. The annual mean standard is not to be exceeded, while the short-term standards are not to be exceeded more than once per year. The trend analyses which follow are for the primary standards.

The trends in ambient concentrations are derived from continuous monitoring instruments which can measure as many as 8760 hourly values per year. The SO_2 measurements reported in this section are summarized into a variety of summary statistics which relate to the SO_2 NAAQS. The statistics on which ambient trends will be reported are the annual arithmetic mean concentration, the second highest annual 24-hour average (summarized midnight to midnight), and the expected annual number of 24-hour exceedances of the 24-hour standard of 0.14 ppm.

3.2.1 Long-term SO_2 Trends: 1978-87

The long-term trend in ambient SO_2, 1978 through 1987, is graphically presented in Figures 3-9 through 3-11. In each figure, the trend at the NAMS is contrasted with the trend at all sites. For each of the statistics presented, a steady downward trend is evident through 1987. Nationally, the annual mean SO_2, examined at 347 sites, decreased at a median rate of approximately 4 percent per year; this resulted in an overall change of about 35 percent (Figure 3-9). The subset of 105 NAMS recorded higher average concentrations but declined at a slightly higher rate of 5 percent per year, with a net change of 41 percent for the 10-year period.

The annual second highest 24-hour values displayed a similar improvement between 1978 and 1987. Nationally, among 347 stations with adequate trend data, the median rate of change was 5 percent per year, with an overall decline of 40 percent (Figure 3-10). The 105 NAMS exhibited a 6 percent per year rate of improvement, for an overall change of 43 percent. The estimated number of exceedances also showed declines for the NAMS as well as for the composite of all sites (Figure 3-11). The vast majority of SO_2 sites, however, do not show any exceedances of the 24-hour NAAQS. Most of the exceedances as well as the bulk of the improvements occurred at source-oriented sites. The national composite estimated number of exceedances decreased 94 percent from 1978 to 1987.

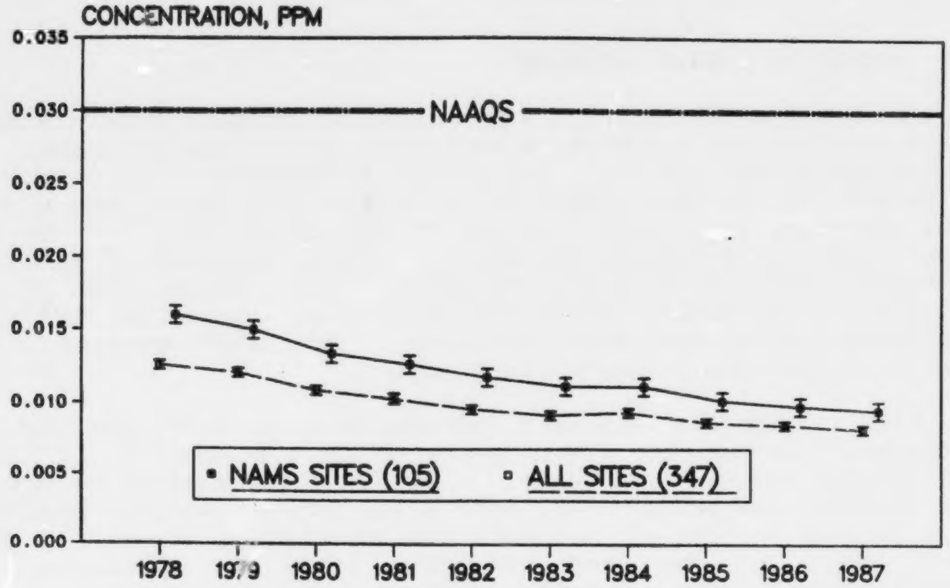


Figure 3-9. National trend in the composite average of the annual average sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

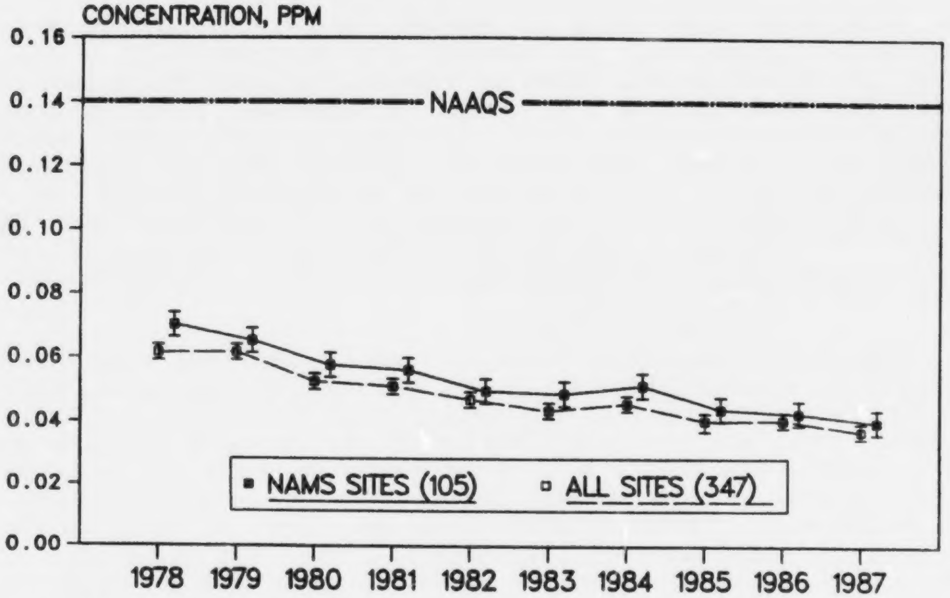


Figure 3-10. National trend in the composite average of the second-highest 24-hour sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

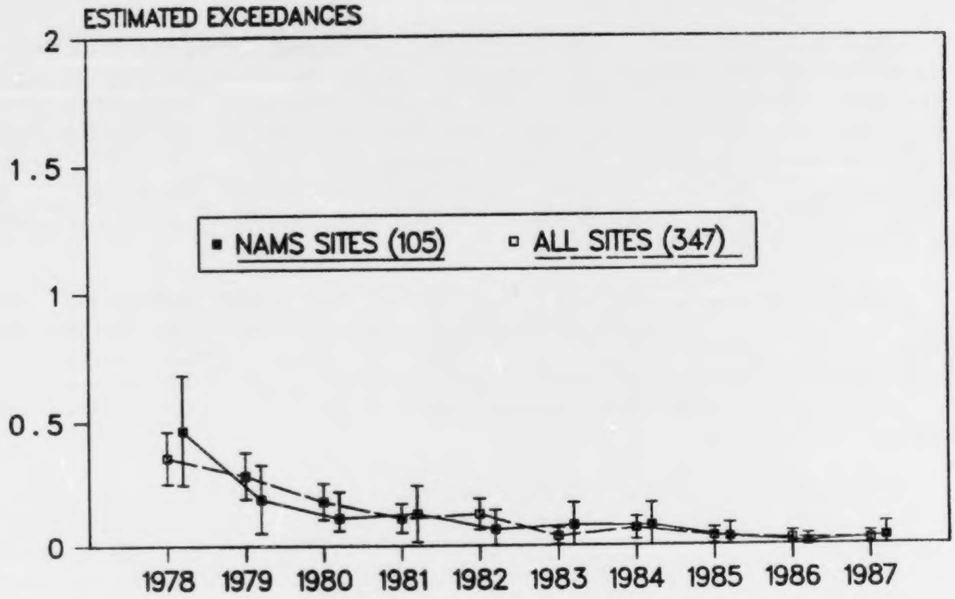


Figure 3-11. National trend in the composite average of the estimated number of exceedances of the 24-hour sulfur dioxide NAAQS at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

The statistical significance of these long-term trends is graphically illustrated in Figures 3-9 to 3-11 with the 95 percent confidence intervals. For both annual averages and peak 24-hour values, the SO_2 levels in 1987 are the lowest in 10 years but are statistically indistinguishable among the last three. Expected exceedances of the 24-hour standard experienced a more rapid decline. For each statistic, 1987 averages are significantly lower than levels before 1983.

The inter-site variability for annual mean and annual second highest 24-hour SO_2 concentrations is graphically displayed in Figures 3-12 and 3-13. These figures show that higher concentrations decreased more rapidly and that the concentration range among sites has also diminished from the late 1970s to the present.

Nationally, sulfur oxide emissions decreased 17 percent from 1978 to 1987 (Figure 3-14 and Table 3-2), reflecting the installation of flue gas desulfurization controls at coal-fired electric generating stations and a reduction in the average sulfur content of fuels consumed. Emissions from other stationary source fuel combustion sectors also declined, mainly due to decreased combustion of coal by these consumers. Sulfur oxide emissions from industrial processes are also significant. Emissions from industrial processes have declined, primarily as the result of controls implemented to reduce emissions from nonferrous smelters and sulfuric acid manufacturing plants.[6]

The disparity between the 35 percent improvement in SO_2 air quality and the 17 percent decrease in SO_2 emissions can be attributed to several factors. SO_2 monitors with sufficient historical data for trends are mostly urban population-oriented, and as such, do not monitor many of the major emitters which tend to be located in more rural areas. Among the 347 trend sites used in the analysis of average SO_2 levels, approximately two-thirds are categorized as population-oriented. The remaining sites include those monitors in the vicinity of large power plants, nonferrous smelters and other industrial sources such as paper mills and steel producing facilities.

The residential and commercial areas, where most monitors are located, have shown sulfur oxide emission decreases comparable to SO_2 air quality improvement. These decreases in sulfur oxide emissions are due to a combination of energy conservation measures and the use of cleaner fuels in the residential and commercial areas.[6] Comparable SO_2 trends have also been demonstrated for monitors located in the vicinity of nonferrous smelters which produce some of the highest SO_2 concentrations observed nationally.[7] Smelter sources represent a majority of SO_x emissions in the intermountain region of the western U.S. Although one-third

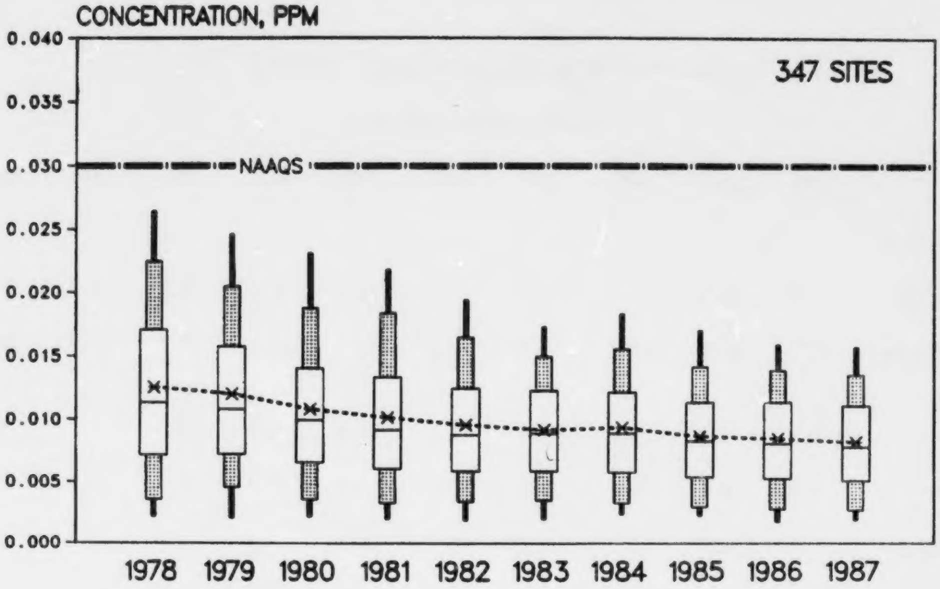


Figure 3-12. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 347 sites, 1978-1987.

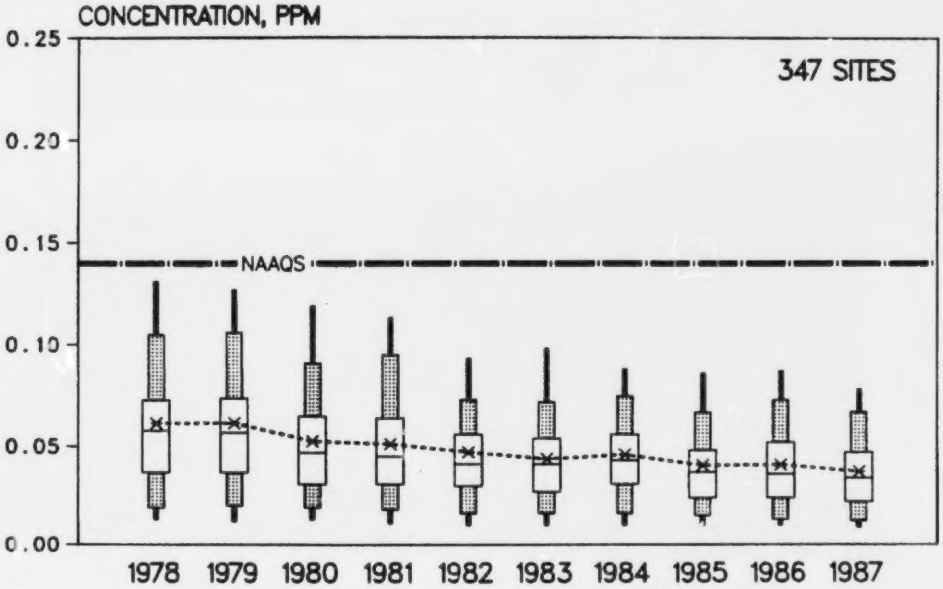


Figure 3-13. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 347 sites, 1978-1987.

Table 3-2. National Sulfur Oxide Emission Estimates, 1978-1987.

(million metric tons/year)

Source Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Transportation	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9
Fuel Combustion	19.5	19.5	18.7	17.8	17.3	16.7	17.4	17.0	16.7	16.4
Industrial Processes	4.3	4.4	3.8	3.9	3.3	3.3	3.3	3.2	3.1	3.1
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	24.6	24.8	23.4	22.6	21.4	20.7	21.5	21.1	20.7	20.4

NOTE: The sums of sub-categories may not equal total due to rounding.

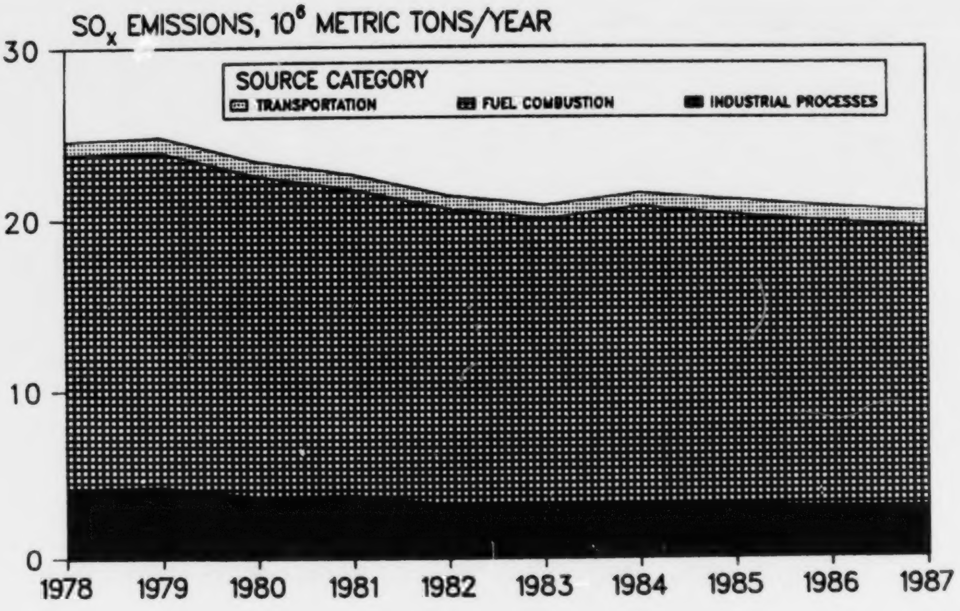


Figure 3-14. National trend in sulfur oxide emissions, 1978-1987.

of the trend sites are categorized as source-oriented, the majority of SO_x emissions are dominated by large point sources. Two-thirds of all national SO_x emissions are generated by electric utilities (96 percent of which come from coal fired power plants). The majority of these emissions, however, are produced by a small number of facilities. Fifty individual plants in 15 states account for one-half of all power plant emissions. In addition, the 200 highest SO_x emitters account for more than 85 percent of all SO_x power plant emissions. These 200 plants account for 61 percent of all SO_x emissions nationally.[14]

Another factor which may account for differences in SO_x emissions and ambient air quality is stack height. The height at which SO_2 is released into the atmosphere has been increasing at industrial sources and power plants.[15,16] This can permit ground level concentrations to decrease at a faster rate than emissions. Under these circumstances, concentrations can, in fact, decrease even if emissions increase.

3.2.2 Recent SO_2 Trends: 1983-87

Figure 3-15 presents boxplots for the 1983-1987 data using 603 SO_2 sites. The 5-year trend shows a 10 percent decline in average concentrations, indicating that the long term trend has continued but has been leveling off. Correspondingly, SO_2 emissions have decreased only 1 percent over the last 5 years.

Regional changes in composite average SO_2 concentrations for the last 3 years, 1985-1987, are shown in Figure 3-16. Most Regions decreased slightly. Between 1986 and 1987, average ambient concentrations have declined 3 percent, corresponding to a 1 percent decrease in total emissions.

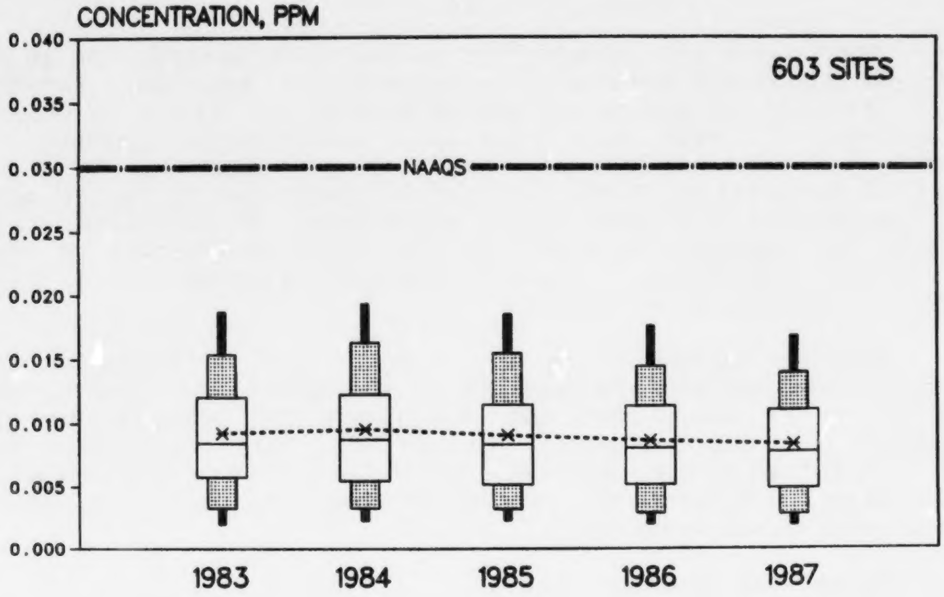


Figure 3-15. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 603 sites, 1983-1987.

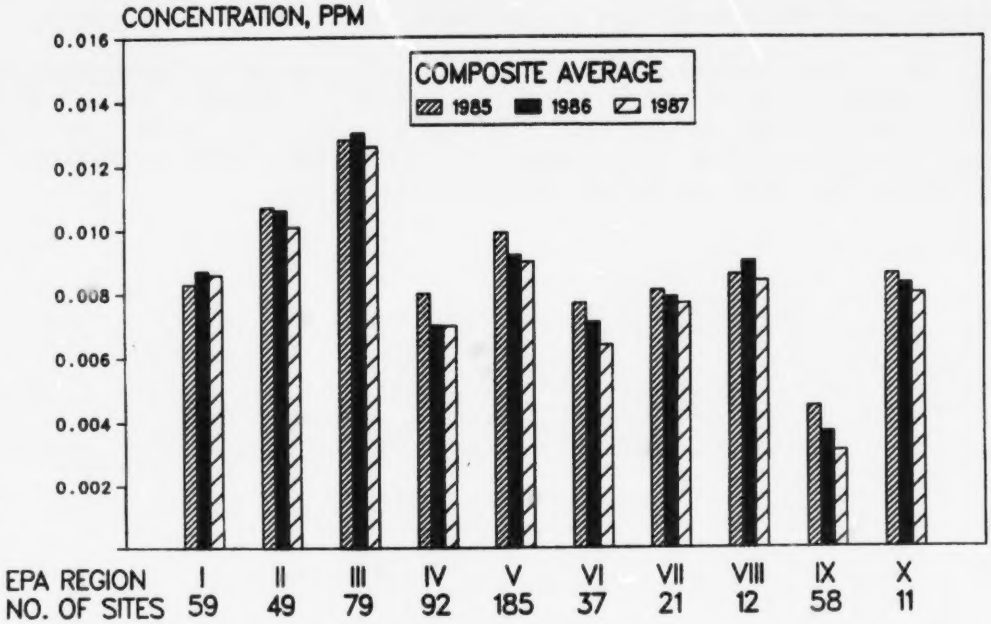


Figure 3-16. Regional comparisons of the 1985, 1986, 1987 composite averages of the annual average sulfur dioxide concentration.

3.3 TRENDS IN CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. Two-thirds of the nationwide CO emissions are from transportation sources, with the largest contribution coming from highway motor vehicles. The NAAQS for ambient CO specify upper limits for both 1-hour and 8-hour averages that are not to be exceeded more than once per year. The 1-hour level is 35 ppm, and the 8-hour level is 9 ppm. This analysis focuses on the 8-hour average results because the 8-hour standard is generally the more restrictive limit. In fact, only four exceedances of the CO 1-hour NAAQS were recorded for the nation during 1987.

Trends sites were selected using the procedures presented in Section 2.1. This resulted in a data base of 198 sites for the 1978-87 10-year period and a data base of 367 sites for the 1983-87 5-year period. There were 54 NAMS sites included in the 10-year data base and 97 NAMS sites in the 5-year data base. This almost two-fold increase in the number of trend sites available for the more recent time period is consistent with the improvement in size and stability of current ambient CO monitoring programs.

3.3.1 Long-term CO Trends: 1978-87

The 1978-87 composite national average trend is shown in Figure 3-17 for the second highest non-overlapping 8-hour CO value for the 198 long-term trend sites and the subset of 54 NAMS sites. During this 10-year period, the national composite average decreased by 32 percent, and the subset of NAMS decreased by 30 percent. The median rate of improvement for this time period is approximately 4 percent per year. After leveling off to no significant change from 1985 to 1986, the trend resumed downward in 1987. Long-term improvement was seen in each EPA Region with median rates of improvement varying from 1 to 7 percent per year. This same trend is shown in Figure 3-18 by a boxplot presentation which provides more information on the distribution of ambient CO levels at the 198 long-term trend sites from year to year. While there is some year to year fluctuation in certain percentiles, the general long-term improvement in ambient CO levels is clear.

Figure 3-19 displays the 10-year trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS. This exceedance rate was adjusted to account for incomplete sampling. The trend in exceedances shows long-term improvement but the rates are much higher than those for the second maximums. The composite average of estimated exceedances improved 91 percent between 1978 and 1987 for the 198 long-term trend sites,

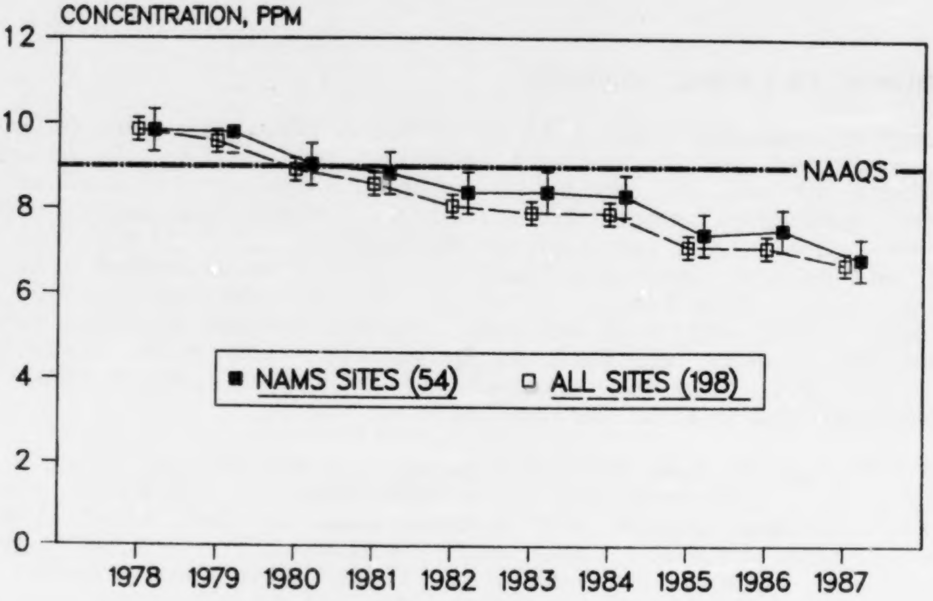


Figure 3-17. National trend in the composite average of the second highest nonoverlapping 8-hour average carbon monoxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

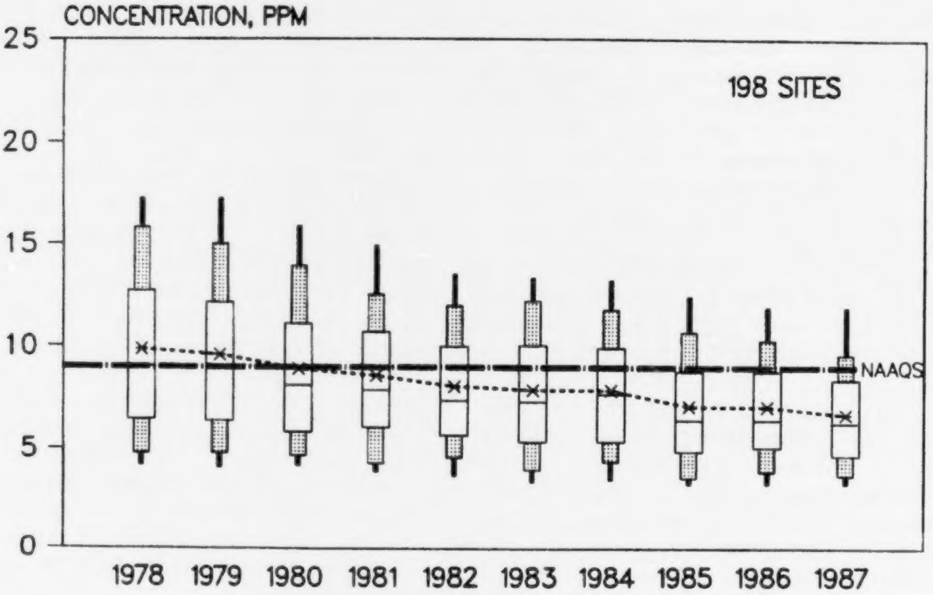


Figure 3-18. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 198 sites, 1978-1987.

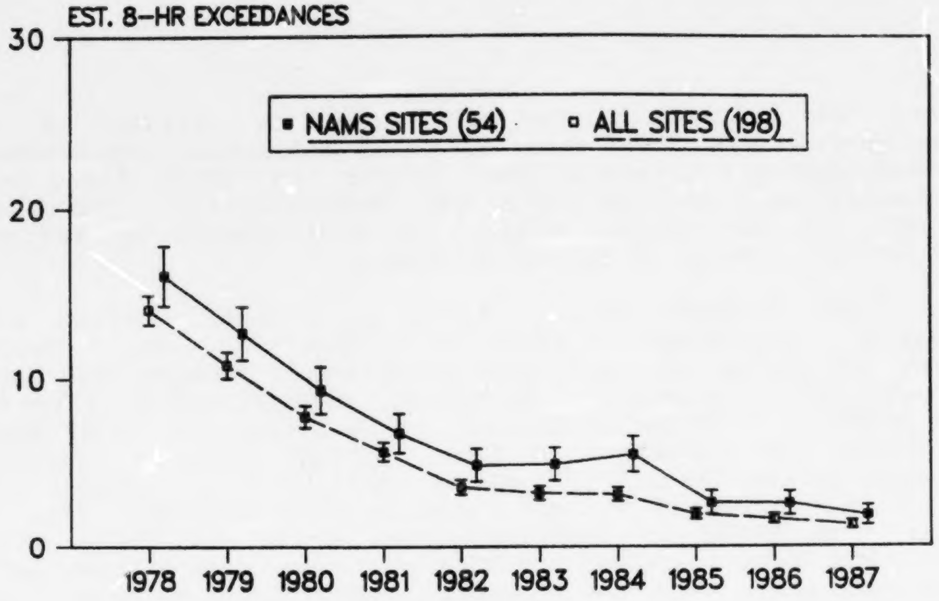


Figure 3-19. National trend in the composite average of the estimated number of exceedances of the 8-hour carbon monoxide NAAQS, at both NAMS and all sites with 95 percent confidence intervals, 1978-87.

while the subset of 54 NAMS showed a similar 88 percent improvement. As noted earlier, these percentage improvements for exceedances are typically much larger than those found for peak concentrations, such as the annual second maximum. The percentage change for the second maxima is more likely to reflect the percentage change in emission levels.

The 10-year 1978-87 trend in national carbon monoxide emission estimates is shown in Figure 3-20 and in Table 3-3. These estimates show a 25 percent decrease between 1978 and 1987. Transportation sources accounted for approximately 74 percent of the total in 1978 and decreased to 66 percent of total emissions in 1987. The contribution from highway vehicles decreased 38 percent during the 1978-87 period, despite a 24 percent increase in vehicle miles of travel. Figure 3-21 contrasts the 10 year increasing trend in vehicle miles travelled (VMT) with the declining trend in carbon monoxide emissions from highway vehicles. This indicates that the Federal Motor Vehicle Control Program (FMVCP) has been effective on the national scale, with controls more than offsetting growth during this period. While there is general agreement between changes in air quality and emissions over this 10-year period, it is worth noting that the emission changes reflect estimated national totals, while ambient CO monitors are frequently located to identify problems. The mix of vehicles and the change in vehicle miles of travel in the area around a specific CO monitoring site may differ from the national averages.

Despite the progress that has been made, CO remains a concern in many urban areas. The characterization of the CO problem is complicated because of the growth and possible changes in traffic patterns that have occurred in many major urban areas. Figure 3-22 shows 1987 CO levels ordered by population for all MSAs with populations greater than 500,000. Cities with incomplete, or missing data, are plotted at the zero concentration level. Studies are in progress to understand better the differences from one city to another and the lack of correspondence between CO levels and city size. There are a variety of possible factors to consider, such as topography, meteorology, and localized traffic flow. The goal is to ensure that the monitoring networks continue to characterize the ambient CO problem adequately. However, these concerns should not overshadow the genuine progress documented over time in areas that have traditionally been the focus of the CO problem.

3.3.2 Recent CO Trends: 1983-87

This section examines ambient CO trends for the 5-year period 1983-87. As discussed in section 2.1, this allows the use of a larger data base, 367 sites versus 198. Figure 3-23 displays the 5-year ambient CO trend in terms of the second highest non-overlapping 8-hour averages. These sites showed a 16 percent improvement between 1983 and 1987. The general patterns are consistent with the longer term data base and, after no change between 1985 and 1986, levels resumed their decline by 6 percent in 1987. Table 3-3 indicates that estimated total CO emissions decreased 14 percent during this 5-year period and that the highway vehicle contribution decreased 22 percent. The increase in CO emissions between 1986 and 1987 is from the increased forest fire activity in the western states during 1987. In fact, emissions from transportation sources decreased 5 percent from 1986 to 1987.

Figure 3-24 shows the composite Regional averages for the 1983-87 time period. Eight of the ten Regions have 1987 composite levels lower than 1986 levels. Increases were observed in Regions VI and X, however the 1987 levels in Region X were less than in 1985, while the increase in Region VI was small. These Regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate Regional differences in absolute concentration levels.

Table 3-3. National Carbon Monoxide Emission Estimates, 1978-1987.

(million metric tons/year)

Source Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Transportation	61.6	56.9	53.5	52.5	50.0	49.3	47.6	45.5	42.8	40.7
Fuel Combustion	5.8	6.6	7.3	7.5	8.0	7.9	8.1	7.2	7.2	7.2
Industrial Processes	7.2	7.1	6.3	5.9	4.4	4.4	4.8	4.6	4.5	4.7
Solid Waste	2.5	2.3	2.2	2.1	2.0	1.9	1.9	2.0	1.7	1.7
Miscellaneous	5.7	6.5	7.6	6.4	4.9	7.7	6.3	5.3	5.0	7.1
Total	82.4	79.4	77.0	74.4	69.4	71.3	68.7	64.6	61.1	61.4

NOTE: The sums of sub-categories may not equal total due to rounding.

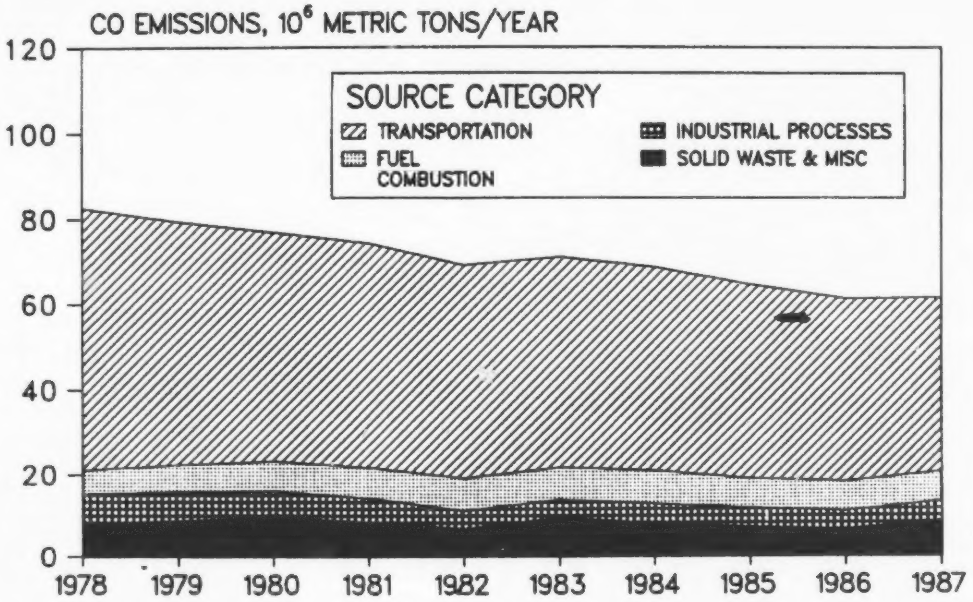


Figure 3-20. National trend in emissions of carbon monoxide, 1978-1987.

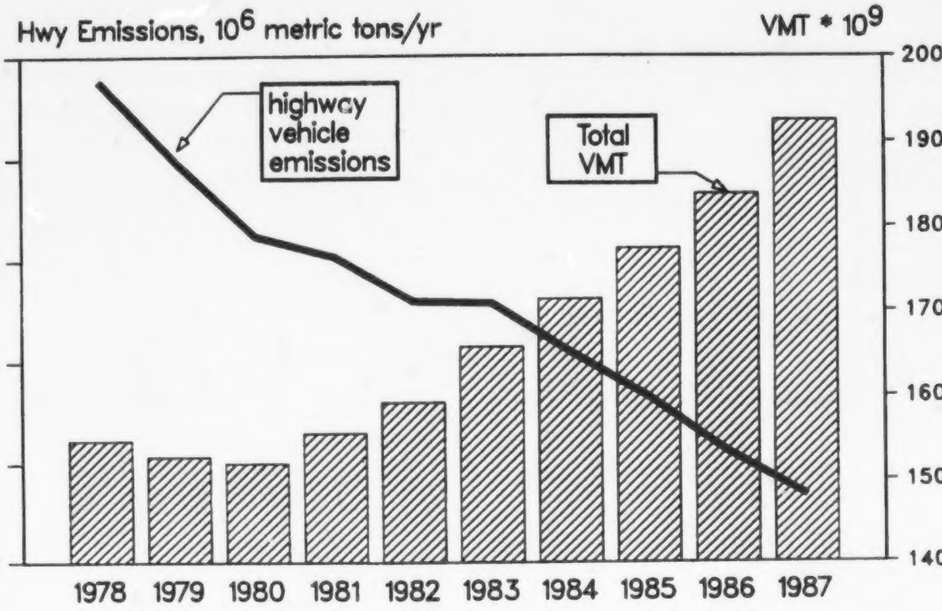


Figure 3-21. Comparison of trends in total National vehicle miles traveled and National highway vehicle emissions, 1978-1987.

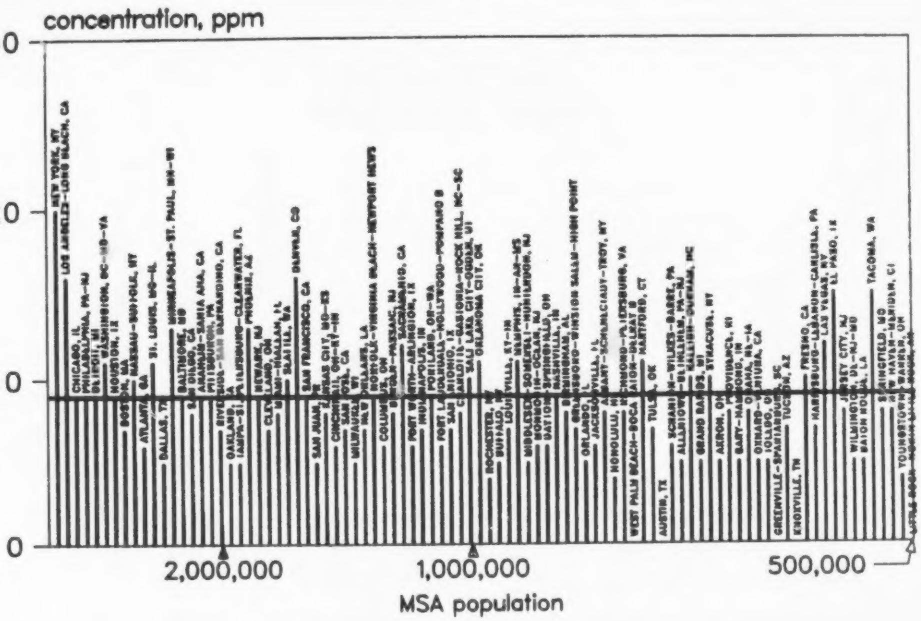


Figure 3-22. Carbon monoxide 1987 second-maximum 8-hour concentrations ordered by MSA population.

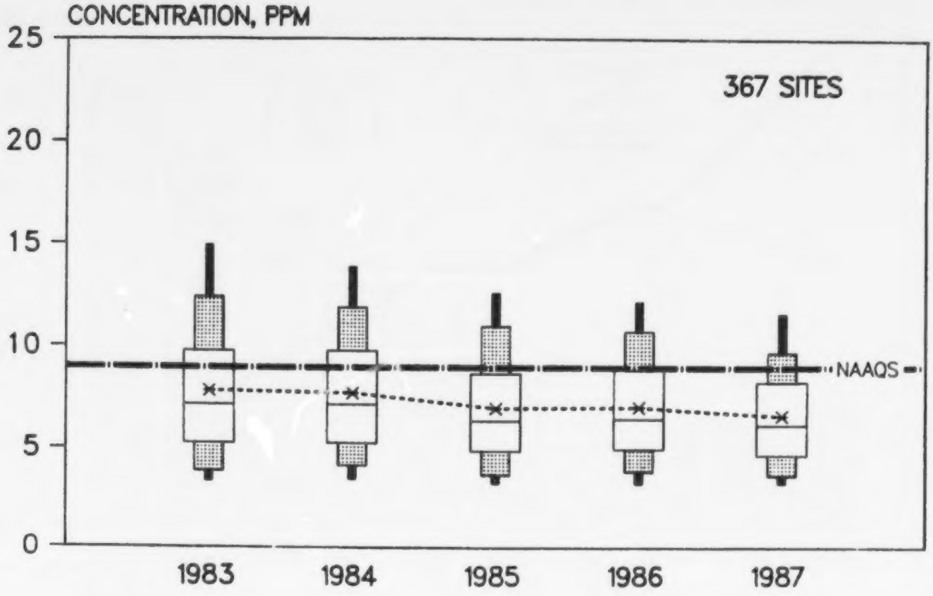


Figure 3-23. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 367 sites, 1983-1987.

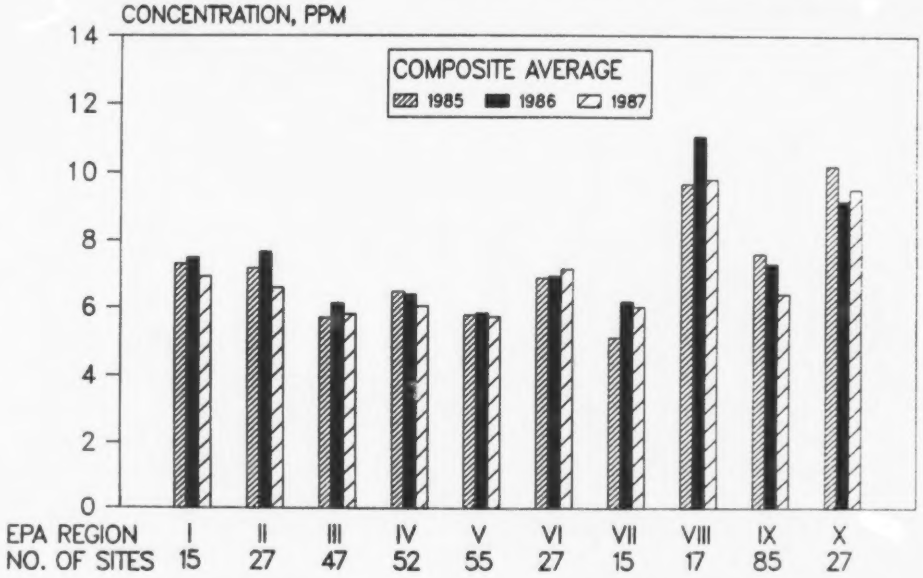


Figure 3-24. Regional comparisons of the 1985, 1986, 1987 composite averages of the second highest nonoverlapping 8-hour average carbon monoxide concentration.

3.4 TRENDS IN NITROGEN DIOXIDE

Nitrogen dioxide (NO_2), a yellowish brown gas, is present in urban atmospheres through emissions from two major sources, transportation and stationary fuel combustion. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant, nitric oxide. NO_2 is measured using either a continuous monitoring instrument, which can collect as many as 8760 hourly values a year, or a 24-hour bubbler, which collects one measurement per 24-hour period. Both types of data are used to compare annual average concentrations with the NO_2 standard of 0.053 parts per million.

In contrast to previous reports,[10,17] the current trends site selection process excluded bubbler data, because only four of the nineteen sites meeting the annual data completeness criteria reported any data in the last 2 years. In fact, only one of the bubbler sites reported any data in 1987. Thus, these sites were omitted from the trends data base, because substituting previous years' levels for missing data would tend to underestimate the average rate of change. A total of 84 continuous sites were selected for the 10-year period and 199 continuous sites for the 5-year data base. Fourteen of the long-term trend sites are NAMS, while 47 NAMS are included in the 1983-87 data base.

3.4.1 Long-term NO_2 Trends: 1978-87

The composite average long-term trend for the nitrogen dioxide mean concentrations at the 84 trend sites and the 14 NAMS sites, is shown in Figure 3-25. Nationally, composite annual average NO_2 levels increased from 1978 to 1979, then decreased through 1983. Following a 3 percent increase in 1984, NO_2 levels declined again by 1 percent in 1987. The 1987 composite average NO_2 level is 12 percent lower than the 1978 level, indicating an overall downward trend during this period. Composite mean NO_2 levels have remained essentially unchanged since 1984. A similar trend is seen for the NAMS sites which, for NO_2, are located only in urban areas with populations of 1,000,000 or greater. Although the composite averages of the NAMS are higher than those of all sites, they also declined by 12 percent during this period.

In Figure 3-25, the 95 percent confidence intervals about the composite means allow for comparisons among the years. There are no significant differences among the recent years, for all sites and for the NAMS. The 1986 and 1987 composite mean NO_2 levels are not significantly different from one another, but they are significantly less than the earlier years 1978 and 1979.

Long-term trends in NO_2 annual average concentrations are also displayed in Figure 3-26 with the use of boxplots. The improvement in the composite average between 1979 and 1987 can generally be seen in the upper percentiles until 1984. The lower percentiles show little change, however.

The trend in the estimated nationwide emissions of nitrogen oxides (NO_x) is similar to the NO_2 air quality trend. Table 3-4 shows NO_x emissions decreasing from 1978 through 1983 then increasing in 1984 and 1985. Total 1987 nitrogen oxide emissions decreased by 8 percent from 1978 levels. Highway vehicle emissions, the source category likely affecting the majority of urban NO_2 sites, decreased by 15 percent during this period. This decrease in the highway vehicle category is similar to the long-term decrease in ambient NO_2 levels of 12 percent. Figure 3-27 shows that the two primary source categories of nitrogen oxide emissions are fuel combustion and transportation, composing 53 percent and 43 percent, respectively, of total 1987 nitrogen oxide emissions.

3.4.2 Recent NO_2 Trends: 1983-87

Figure 3-28 uses the boxplot presentation to display recent trends in nitrogen dioxide annual mean concentrations for the years 1983-87. Focusing on the past five years, rather than the last ten years, more than doubles the number of sites, from 84 to 199, available for the analysis. Although the composite means from the recent period are 1 to 2 percent higher than the long-term means, the trends are consistent for the two data bases.

The composite average NO_2 level at the 199 trend sites increased 2 percent from 1983 to 1984 and remained constant during the last four years. During this same period, nitrogen oxide emissions increased by 3 percent. Between 1984 and 1987, the NO_2 composite average remained constant, while nitrogen oxide highway vehicle emissions decreased by 3 percent.

Regional trends in the composite average NO_2 concentrations for the years 1985-87 are displayed in Figure 3-29 with bar graphs. Region X, which did not have any NO_2 sites which met the 5-year trends data completeness and continuity criteria, is not shown. The pattern of the year-to-year changes is mixed among the Regions. Although the national composite average showed no change during this period, seven of the ten Regions showed small increases from 1986 to 1987. Only Regions VIII and IX recorded a decrease in the last 2 years. As discussed in Section 4.0, the Los Angeles metropolitan area (Region IX) is the only area which exceeded the NO_2 standard during this period.

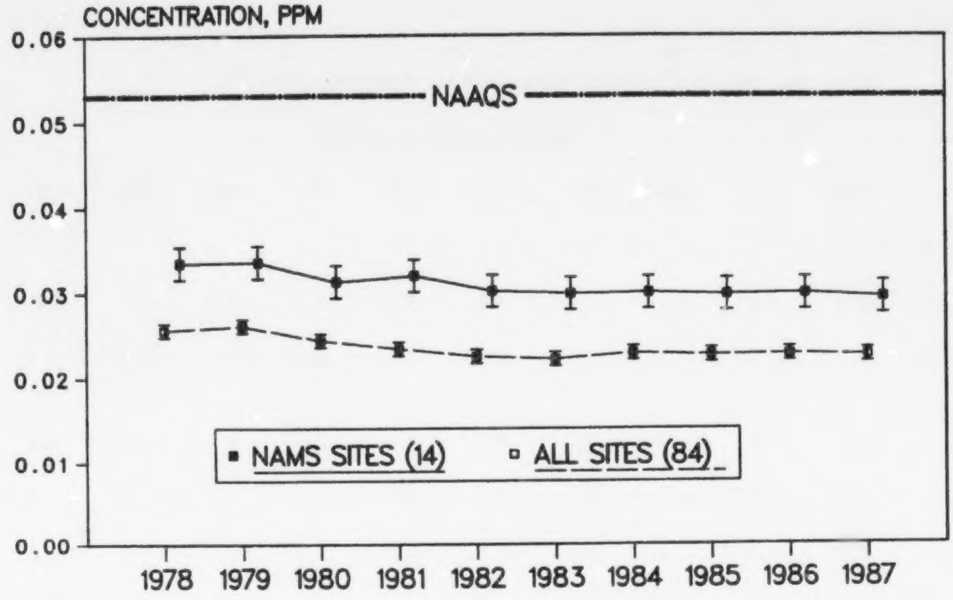


Figure 3-25. National trend in the composite average of nitrogen dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

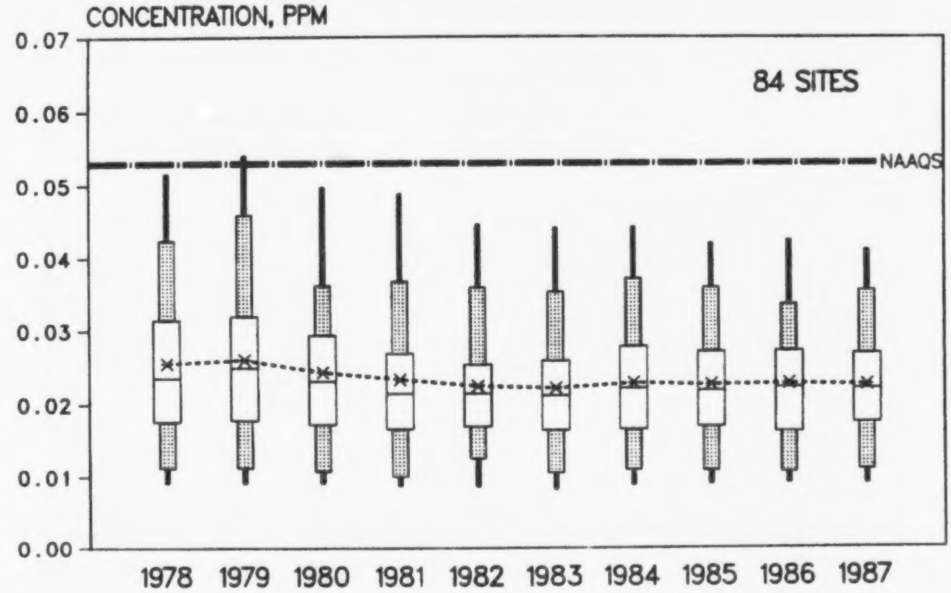


Figure 3-26. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 84 sites, 1978-1987.

Table 3-4. National Nitrogen Oxides Emission Estimates, 1978-1987.

(million metric tons/year)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Source Category										
Transportation	9.8	9.6	9.3	9.4	9.0	8.5	8.6	8.8	8.5	8.4
Fuel Combustion	10.3	10.5	10.1	10.0	9.8	9.6	10.2	10.2	10.0	10.3
Industrial Processes	0.7	0.7	0.7	0.6	0.5	0.5	0.6	0.6	0.6	0.6
Solid Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1
Total	21.1	21.1	20.4	20.4	19.6	19.0	19.7	19.8	19.3	19.5

NOTE: The sums of sub-categories may not equal total due to rounding.

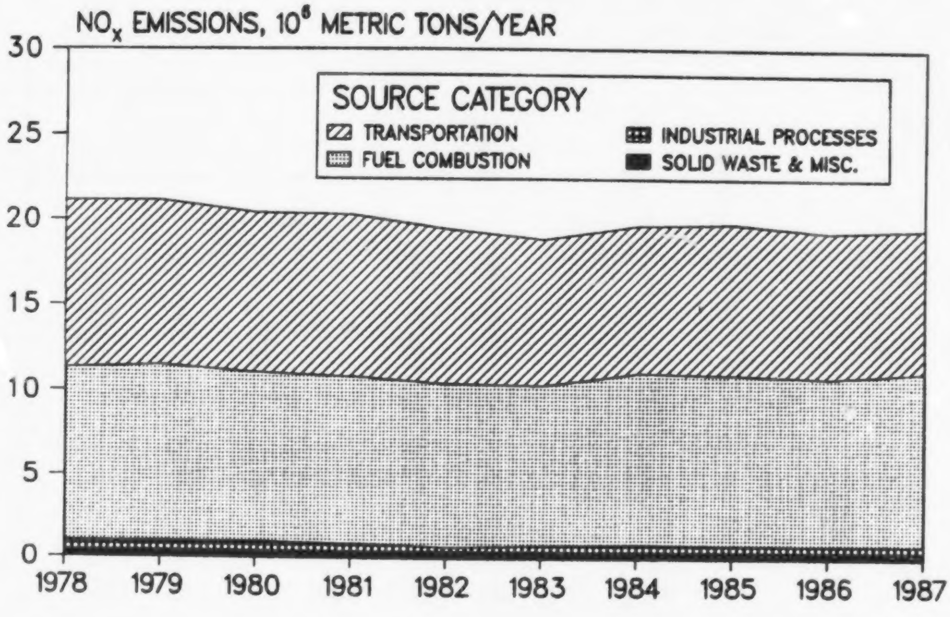


Figure 3-27. National trend in nitrogen oxides emissions, 1978-1987.

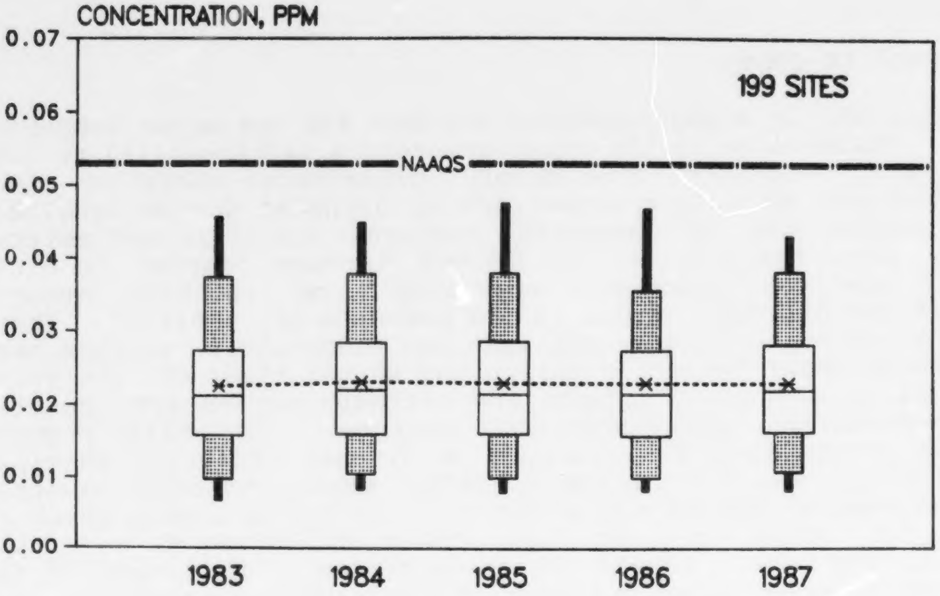


Figure 3-28. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 199 sites, 1983-1987.

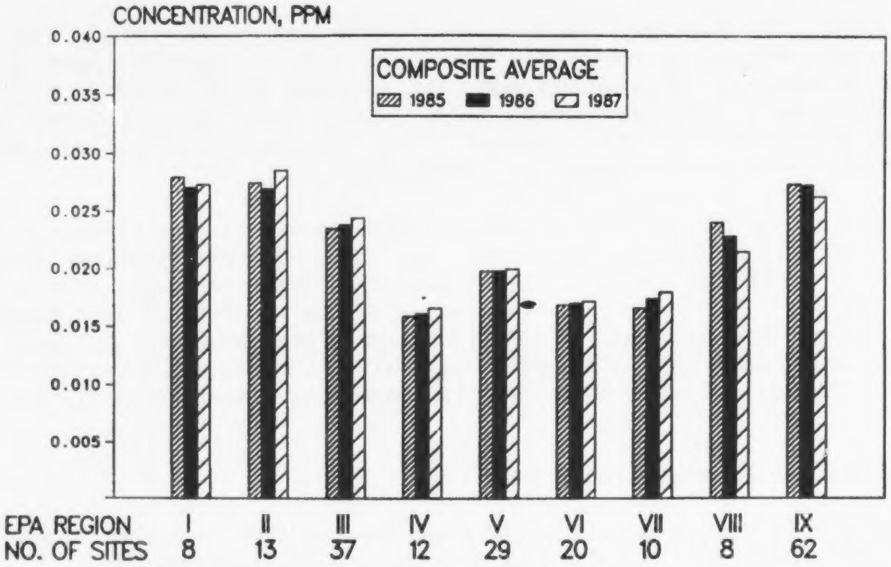


Figure 3-29. Regional comparisons of 1985, 1986, 1987 composite averages of the annual mean nitrogen dioxide concentration.

3.5 TRENDS IN OZONE

Ozone (O_3) is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation given off by the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak ozone levels occur typically during the warmer times of the year. Both volatile organic compounds and nitrogen oxides are emitted by transportation and industrial sources. Volatile organic compounds are emitted from sources as diverse as autos, chemical manufacturing, and dry cleaners, paint shops and other sources using solvents. The strong seasonality of ozone levels makes it possible for areas to limit their ozone monitoring to a certain portion of the year, termed the ozone season. The length of the ozone season varies from one area of the country to another. May through October is typical but states in the south and southwest may monitor the entire year. Northern states would have shorter ozone seasons such as May through September for North Dakota. This analysis uses these ozone seasons on a state by state basis to ensure that the data completeness requirements apply to the relevant portions of the year.

The O_3 NAAQS is defined in terms of the daily maximum, that is, the highest hourly average for the day, and it specifies that the expected number of days per year with values greater than 0.12 ppm should not be greater than one. Both the annual second highest daily maximum and the number of daily exceedances during the ozone season are considered in this analysis.

The trends site selection process, discussed in Section 2.1, resulted in 274 sites being selected for the 1978-87 period and 522 sites qualifying for the 1983-87 5-year data base. Ninety-eight of the long-term trends sites were NAMS, and 181 NAMS sites were included in the 5-year trends data base. In both cases, the 5-year data base is much larger than the 10-year data base, which reflects the improvement in ambient ozone monitoring networks.

3.5.1 Long-term O_3 Trends: 1978-87

Figure 3-30 displays the 10-year composite average trend for the second highest day during the ozone season for the 274 trends sites and the subset of 98 NAMS sites. Although the 1987 composite average for the 274 trend sites is 16 percent lower than the 1978 average, this comparison is affected by a calibration change for ozone measurements that occurred in the 1978-79 period.[18] This complication has been discussed in previous reports, as have the reasons that it is difficult to quantify this effect.[7,9,10] The stippled portion of Figure 3-30 indicates data affected by measurements taken before the calibration change. Considering the data after this calibration change, there was a 9 percent improvement in ozone levels between 1979 and 1987. This has not been a smooth downward trend, and there has been year-to-year fluctuation, with 1983 clearly being high. This has been attributed in part to 1983 meteorological conditions in some areas of the country that were more conducive to ozone formation.

This same 10-year trend for the annual second highest daily maximum for the 274 site data base is displayed in Figure 3-31 by the boxplot presentation. Again, the stippled portion indicates those years affected by data preceding the calibration change, and 1983 is clearly higher than adjacent years. The 1979, 1980 and 1983 values are similarly high, while the remaining years in the 1979-87 period are generally lower, with 1986 being the lowest, on average. In 1987, ozone concentrations generally returned to the levels recorded during 1984 and 1985 except for the peak sites, which were considerably lower than these earlier years. Figure 3-32 depicts the 1978-87 trend for the composite average number of ozone exceedances. This statistic is adjusted for missing data, and it reflects the number of days that the ozone standard is exceeded during the ozone season. The stippled area again indicates the time period when comparisons would be affected by the calibration change, so that the 51 percent decrease between 1978 and 1987 incorporates the effect of the calibration change. Since 1979, the expected number of exceedances decreased 38 percent for the 274 sites and 37 percent for the 98 NAMS. As with the second maximum, the 1979, 1980 and 1983 values are higher than the other years in the 1979-87 period.

Table 3-5 and Figure 3-33 display the 1978-87 emission trends for volatile organic compounds (VOC) which, along with nitrogen oxides, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. Total VOC emissions are estimated to have decreased 17 percent between 1978 and 1987. Between 1978 and 1987, VOC emissions from highway vehicles are estimated to have decreased 36 percent, despite a 24 percent increase in vehicle miles of travel during this time period (see Figure 3-21). Total VOC emissions declined 17 percent since the calibration change.

3.5.2 Recent O_3 Trends: 1983-87

This section discusses ambient O_3 trends for the 5-year time period 1983-87. Using this period permits the use of a larger data base of 522 sites, compared to 274 for the 10-year period. Figure 3-34 uses a boxplot presentation of the annual second maximum daily value at these 522 sites. The national composite average decreased 8 percent between 1983 and 1987 while Table 3-5 indicates that total VOC emissions are estimated to have decreased by 4 percent during this period. After declining during the last 4 years, the composite average increased 5 percent from 1986 to 1987. The increase in 1987 ozone levels is likely from the hot, dry meteorological conditions recorded in much of the Eastern U.S. during Summer 1987. The most obvious feature of Figure 3-34 is that 1983 levels were clearly higher than those of the other years. Previous reports[7,9,10] have discussed how these 1983 ozone levels were influenced that year by meteorological conditions being more conducive to ozone formation than in the adjacent years.

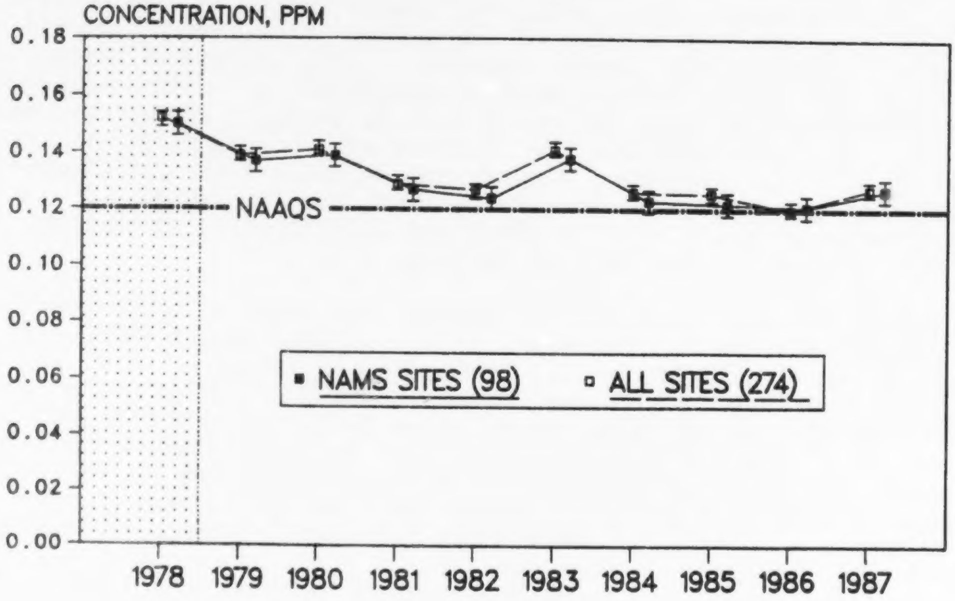


Figure 3-30. **National trend in the composite average of the second highest maximum 1-hour ozone concentration at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.**

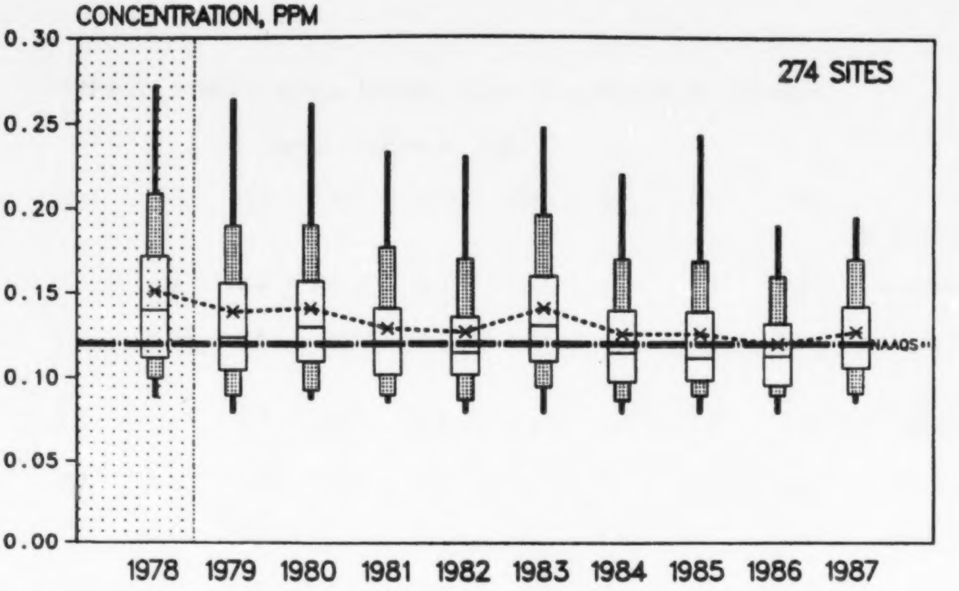


Figure 3-31. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 274 sites, 1978-1987.

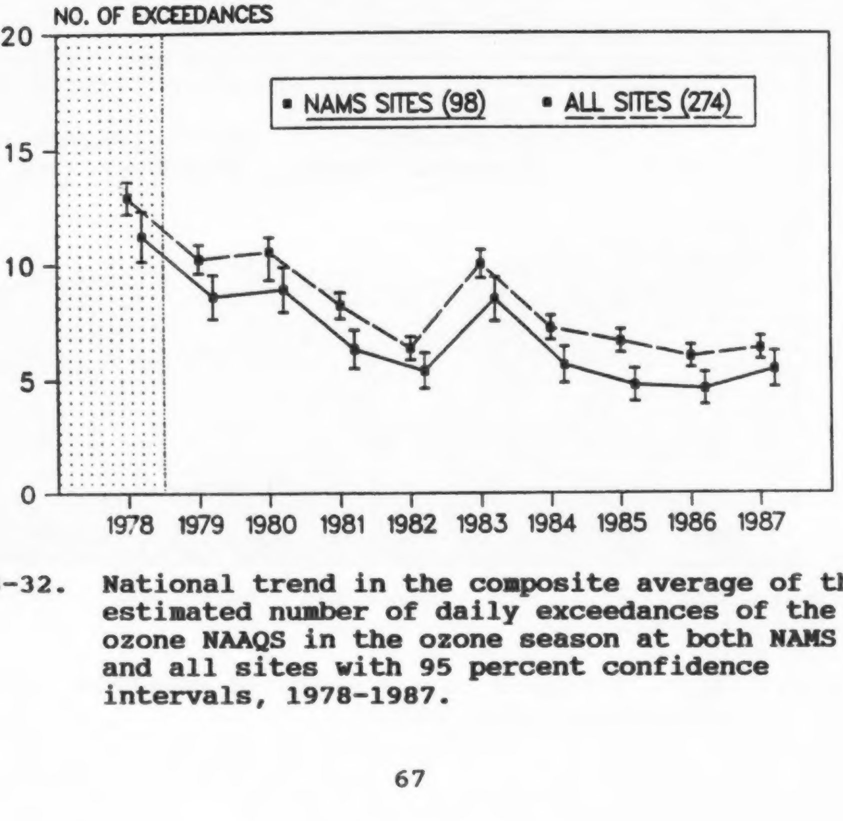


Figure 3-32. National trend in the composite average of the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95 percent confidence intervals, 1978-1987.

Table 3-5. National Volatile Organic Compound Emission Estimates, 1978-1987.

(million metric tons/year)

Source Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Transportation	8.7	9.1	7.4	7.2	6.8	6.7	6.8	6.4	6.2	6.0
Fuel Combustion	1.6	1.9	2.2	2.3	2.5	2.6	2.6	2.3	2.3	2.3
Industrial Processes	9.9	9.9	9.2	8.3	7.5	7.9	8.8	8.5	8.1	8.3
Solid Waste	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Miscellaneous	2.7	2.9	2.9	2.5	2.2	2.7	2.7	2.2	2.2	2.4
TOTAL	23.5	23.5	22.3	21.0	19.7	20.4	21.5	20.1	19.3	19.6

NOTE: The sums of sub-categories may not equal total due to rounding.

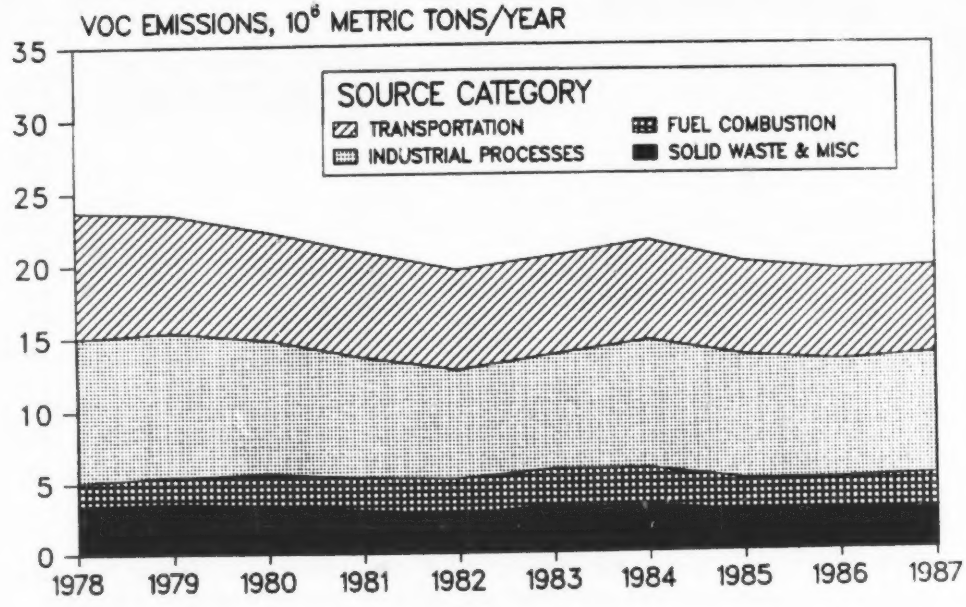


Figure 3-33. National trend in emissions of volatile organic compounds, 1978-1987.

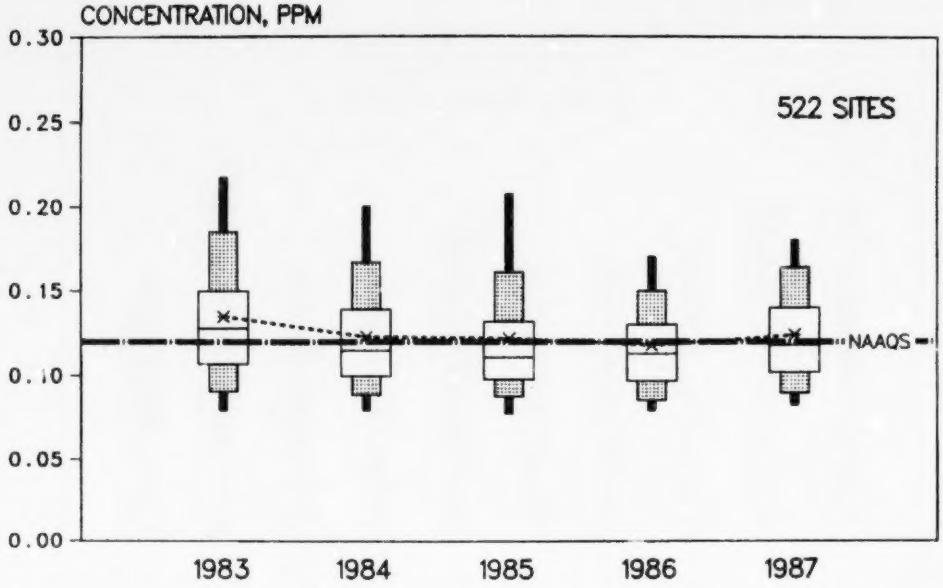


Figure 3-34. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentrations at 522 sites, 1983-1987.

Figure 3-35 presents a Regional comparison for 1985, through 1987 of the composite average second highest daily maximum 1-hour ozone concentration. Again it is worth noting that these 1985-87 values are generally lower than those of 1983. In seven of these Regions the 1987 values were higher than in 1986. In contrast, Regions VIII and X recorded the lowest levels of the last 3 years. Data for 1987 suggest that meteorological conditions may again have been conducive to ozone formation and may have contributed to increased ozone levels in the eastern half of the country. Studies have shown that peak ozone levels are highly correlated with maximum daily temperature and with the number of days with greater than 90 degrees Fahrenheit (°F).[19] Figure 3-36 uses the Regional bar chart format to present the number of days greater than 90° F in 1985-87 for selected cities in these Regions.[20] Although there is considerable similarity between the patterns for the air quality data (Figure 3-35) and the patterns for this simple meteorological indicator, peak ozone levels result from a complex process, as illustrated by the multi-Region ozone episode described in the following section.

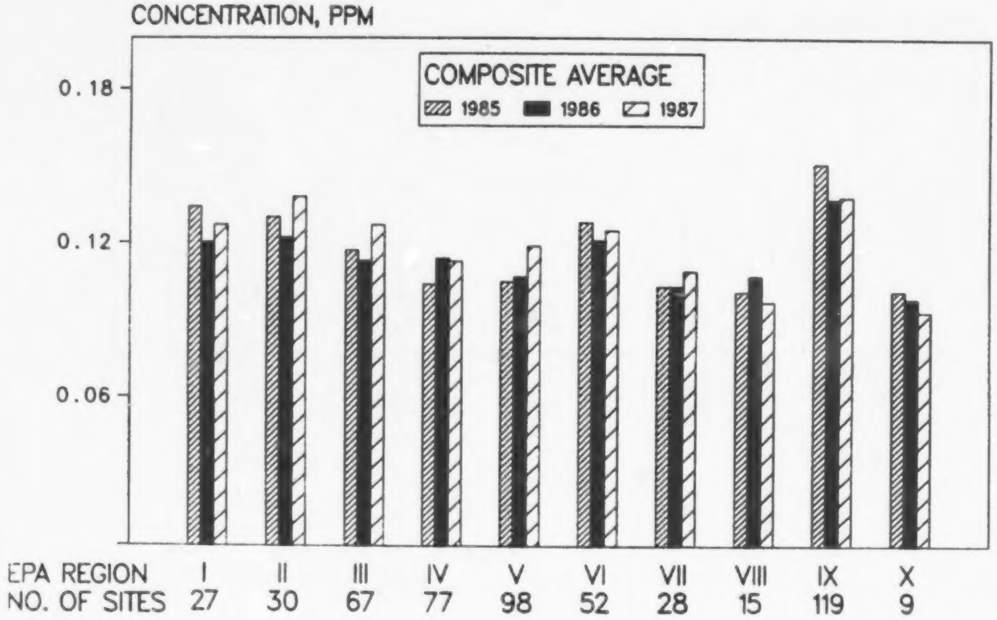


Figure 3-35. Regional comparisons of the 1985, 1986, 1987 composite averages of the second-highest daily 1-hour ozone concentrations.

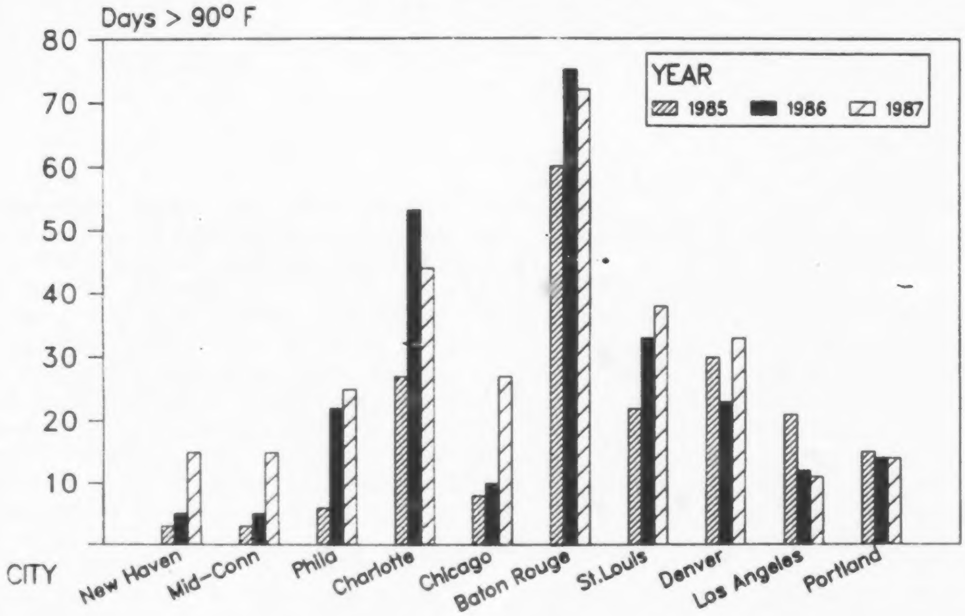


Figure 3-36. Regional comparisons of the number of days greater than 90°F in 1985, 1986, 1987 for selected cities.

3.5.3 Chronology of a Multi-Regional Ozone Episode, June 17-20, 1987

Because of the recent interest in ozone, a June 1987 multi-region episode was examined, using the geographic information system (GIS) ARC/INFO.[21] The system was used to generate isopleths based on the daily maxima of hourly ozone concentrations from all sites in the northeast and north central areas of the United States. Data were also obtained from Canadian sites, in Ontario, during the same time period.[22] The Canadian data helped define the isopleths near the Great Lakes. The GIS was used to display the isopleths as levels of grey shading (Figures 3-37 through 3-40). These isopleths involve a certain amount of smoothing, so that the maps provide a simplified overview and are not intended to provide precise city specific concentrations. The episode begins on Wednesday, June 17 and ends on Saturday, June 20.

Wednesday, June 17: A strong high pressure system is located in southeastern Canada, and the whole study area is experiencing high temperatures from the high 70s to the low 90s, with small amounts of precipitation in New England. Ozone readings above the standard are observed in the Chicago and Milwaukee areas and at one site in Parkersburg, West Virginia (Figure 3-37).

Thursday, June 18: The high pressure system is now over Pennsylvania, and a strong low pressure system has moved into southern Canada. No precipitation has been observed in the entire region. Areas of high ozone concentrations are centered on Chicago, Milwaukee, northwest Indiana, eastern Ohio, western Pennsylvania, and central Maryland (Figure 3-38).

Friday, June 19: The high pressure system has moved off the coast of New Jersey, with high temperatures in the 80s to 90s. Again, no precipitation has been observed in the entire area. High ozone concentrations are now observed in eastern Michigan, western Pennsylvania, and from eastern Pennsylvania through the northeast corridor (Figure 30-39).

Saturday, June 20: A weak cold front moving into the area from the northwest has reached Pennsylvania. Precipitation is observed along this front, and maximum temperatures have reached the mid-90's to the east of the front. High ozone concentrations are observed in central New Jersey, with very high concentrations centered on New York City (Figure 3-40).

These displays indicate an initiation of an episode in the Chicago-Milwaukee area which is followed by a general eastward movement ending in New York City. The episode tracks the basic meteorological events occurring during this period. By Sunday no elevated readings of ozone are reported, and the episode has ended.

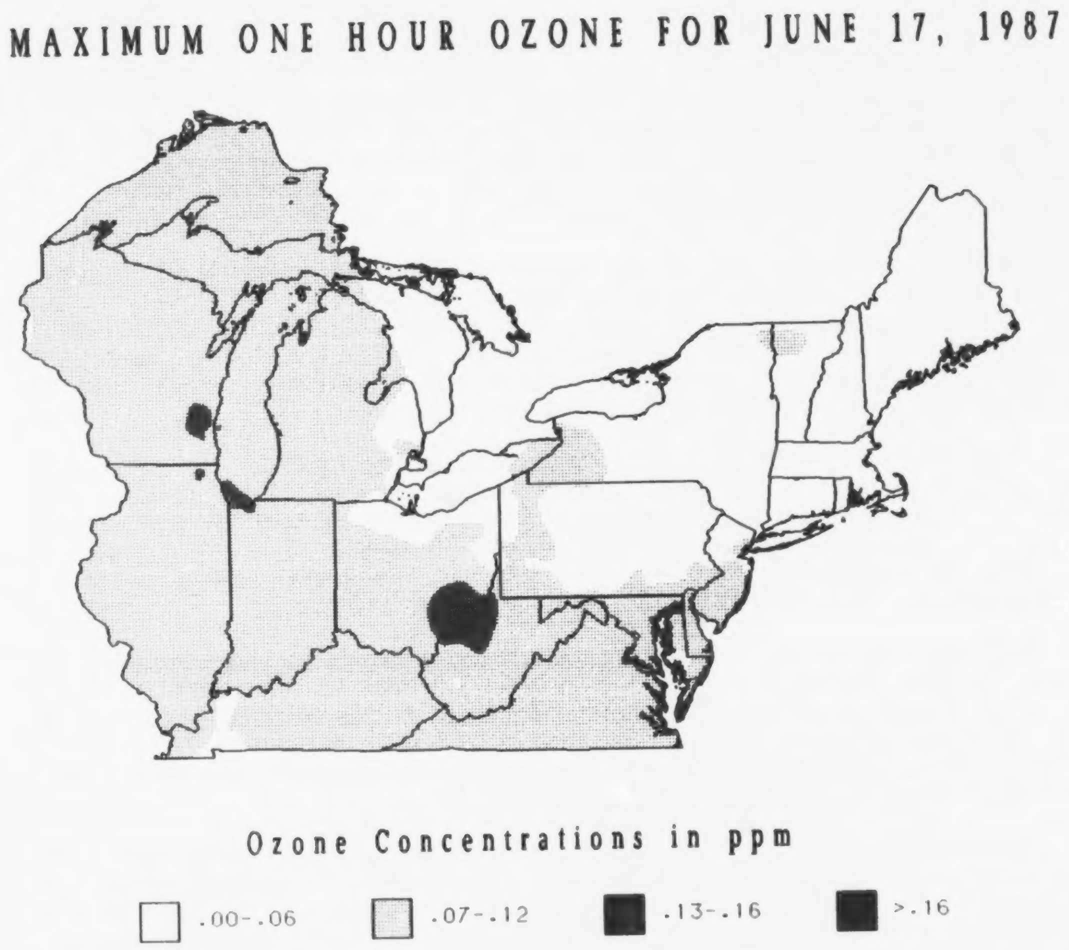

MAXIMUM ONE HOUR OZONE FOR JUNE 17, 1987
Ozone Concentrations in ppm
□ .00-.06
▨ .07-.12
■ .13-.16
■ >.16

Figure 3-37. Isopleths of ozone daily maximum 1-hour concentrations for June 17, 1987.

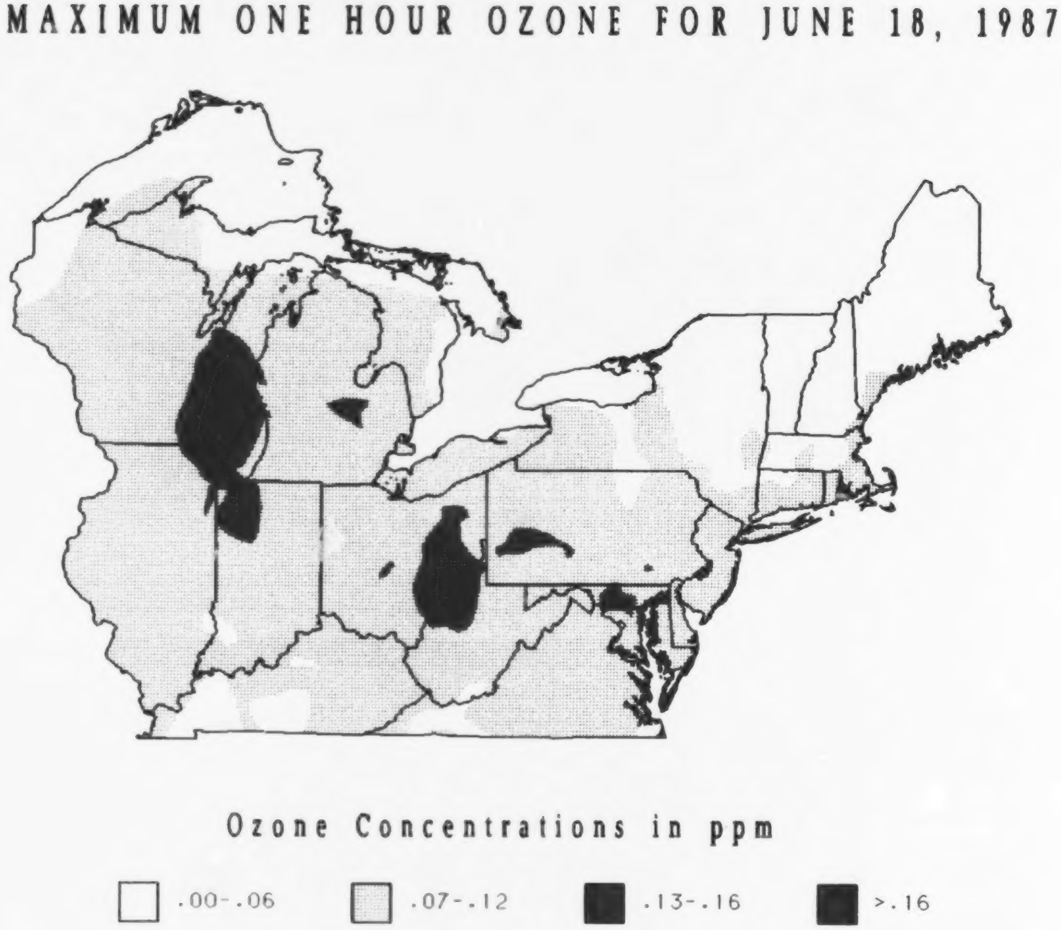

MAXIMUM ONE HOUR OZONE FOR JUNE 18, 1987
Ozone Concentrations in ppm
.00-.06
.07-.12
.13-.16
>.16

Figure 3-38. Isopleths of ozone daily maximum 1-hour concentrations for June 18, 1987.

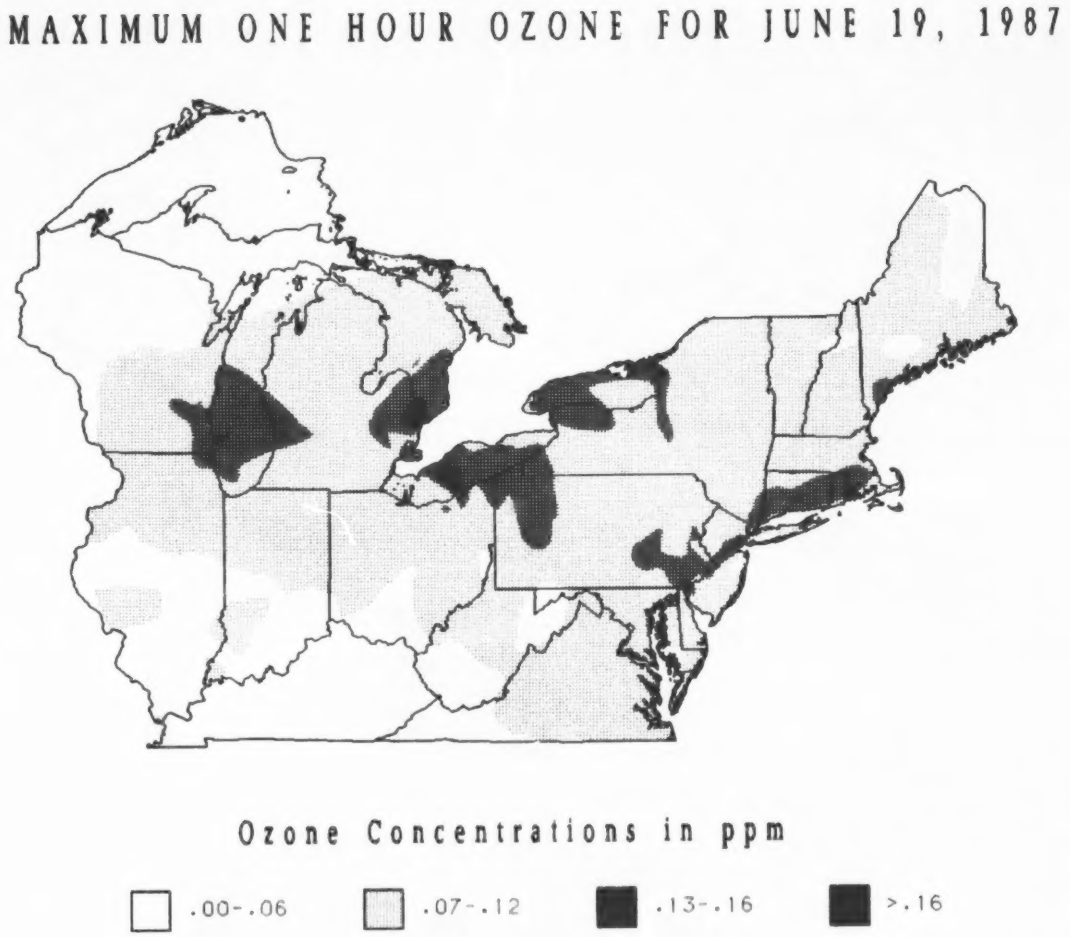

MAXIMUM ONE HOUR OZONE FOR JUNE 19, 1987
Ozone Concentrations in ppm
.00-.06
.07-.12
.13-.16
>.16

Figure 3-39. Isopleths of ozone daily maximum 1-hour concentrations for June 19, 1987.

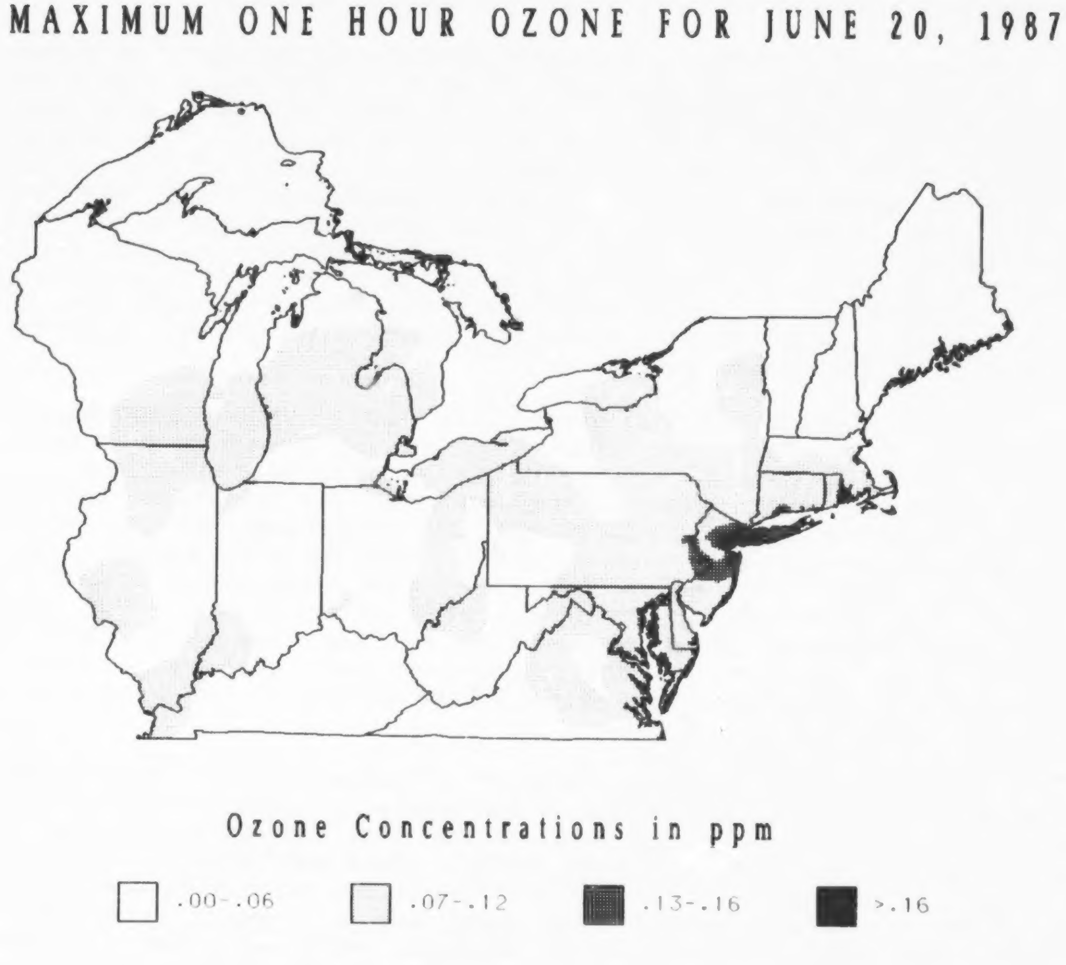

MAXIMUM ONE HOUR OZONE FOR JUNE 20, 1987
Ozone Concentrations in ppm
.00-.06
.07-.12
.13-.16
>.16

Figure 3-40. Isopleths of ozone daily maximum 1-hour concentrations for June 20, 1987.

3.5.4 Preview of 1988 Ozone Trends

The summer of 1988, with its very hot, dry weather and stagnant conditions, was highly conducive to peak ozone levels. Unusually high ozone levels and numerous exceedances were reported beginning in early June. In response to public concern and media attention, EPA initiated a cooperative program with the state and local air pollution control agencies for the early reporting of ozone summary data.[23] Preliminary, unvalidated data were reported to EPA for a subset of peak ozone monitoring sites.

Figure 3-41 provides a Regional overview of how hot the summer of 1988 was compared to the past 57 years. Nationally, 1988 was the third hottest summer since 1931. In the north central states, this was the hottest summer in almost 60 years.[24] This single meteorological indicator, average daily temperature, does not completely describe the hot, stagnant conditions which occurred during June in the Southeast and which produced record numbers of exceedances that month. The observed exceedances of the ozone standard in these two regions are shown in Figure 3-42 and Figure 3-43, respectively. There are numerous sites with more than 10 exceedances, which is 10 times the allowable average expected exceedance rate of one per year.

Meteorological conditions during 1983 were also highly conducive to ozone formation.[9] Figure 3-44 presents a boxplot comparison of 1983 and 1988 ozone levels for the subset of 228 sites with data available for both years. The composite average of the annual daily maximum 1-hour concentration for 1988 is 5 percent higher than the 1983 value. Except for peak percentiles, which are lower than those for 1983, the 1988 distribution is higher, but more compact, than the 1983 distribution. The 95th percentile level of the 1983 boxplot is lower than that shown in Figure 3-34, because of the under-representation of southern California sites in this preliminary data subset of early reporting sites.

Figure 3-45 shows a preliminary estimate of the trend in the composite average of the annual daily maximum 1-hour concentration for the period 1978 through 1988. The 1988 composite average is 14 percent higher than the 1987 level. This estimate is based on a subset of 272 sites which reported data for both 1987 and 1988. In order to eliminate any bias from unequal Regional response rates, the Regional percentage changes were adjusted for the relative number of sites in the long-term trends data base. This estimate should be viewed as preliminary, because the 1988 data have not yet been subjected to the complete quality assurance process.

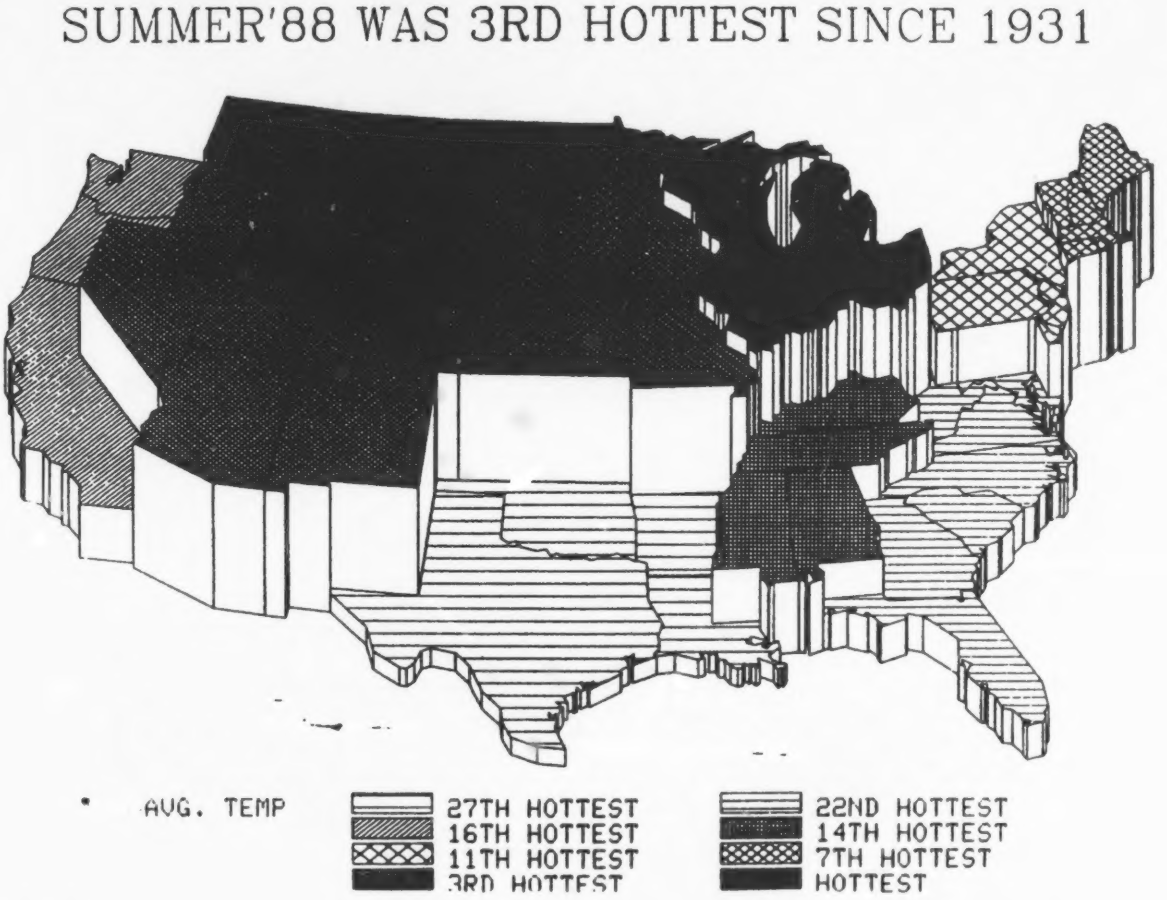

SUMMER'88 WAS 3RD HOTTEST SINCE 1931
AVG. TEMP
27TH HOTTEST
22ND HOTTEST
16TH HOTTEST
14TH HOTTEST
11TH HOTTEST
7TH HOTTEST
3RD HOTTEST
HOTTEST

Figure 3-41. **Summer '88 was 3rd hottest since 1931. (Source: USA Today, September 6, 1988).**

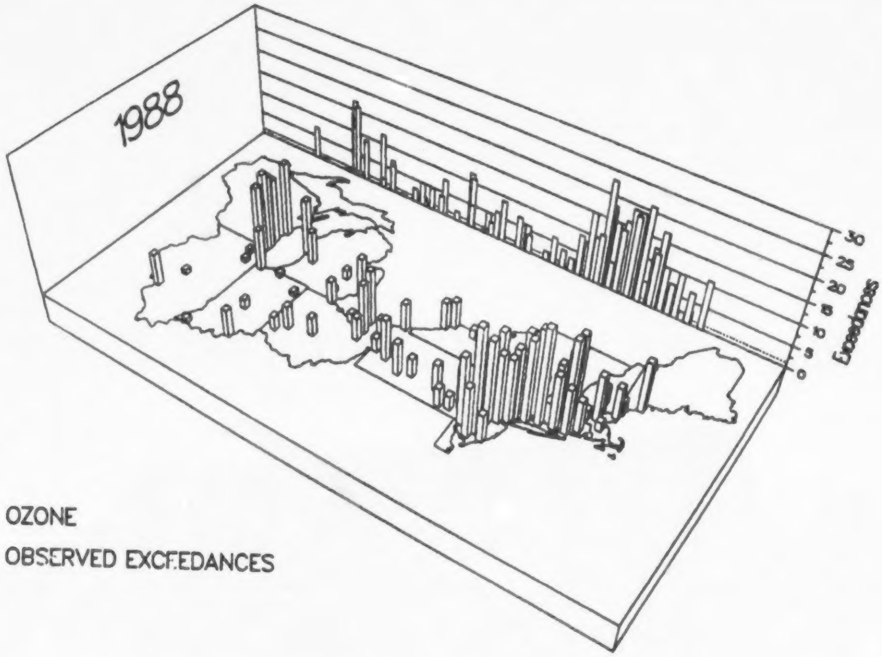


Figure 3-42. Ozone exceedances for selected cities in the north central and northeastern U.S., 1988.

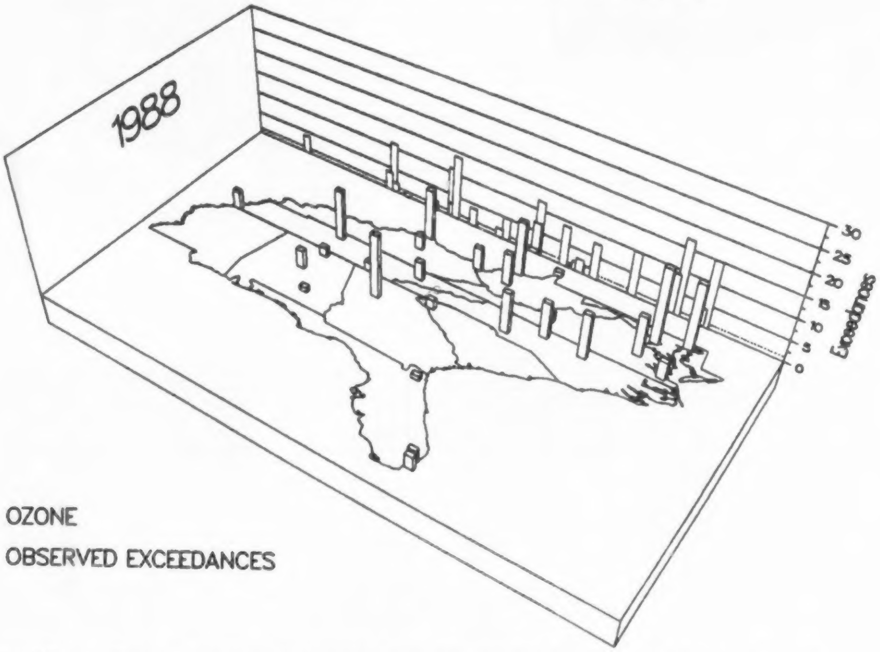


Figure 3-43. Ozone exceedances for selected cities in the southeastern U.S., 1988.

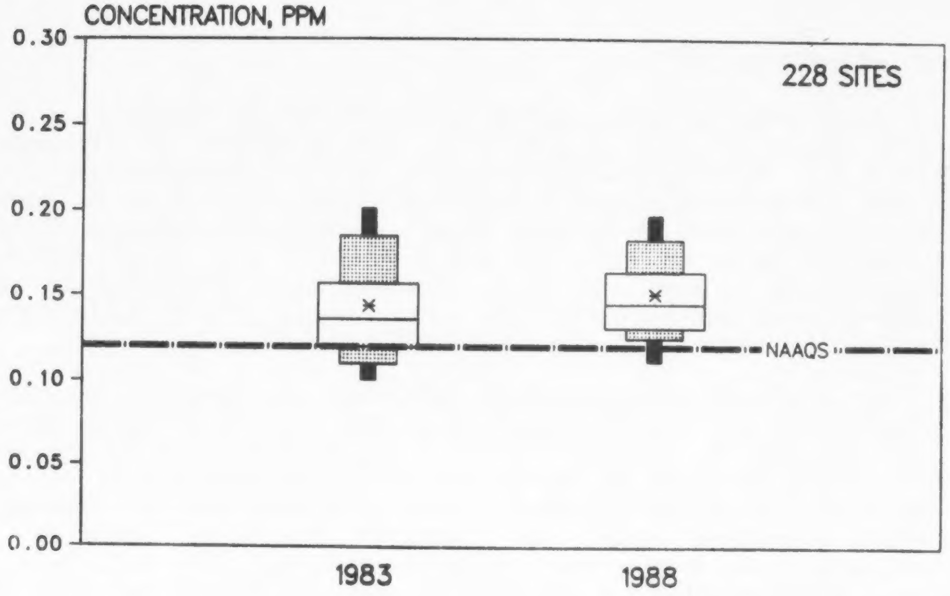


Figure 3-44. Boxplot comparison of 1983 and 1988 annual second highest daily maximum 1-hour ozone concentrations at 228 paired sites.

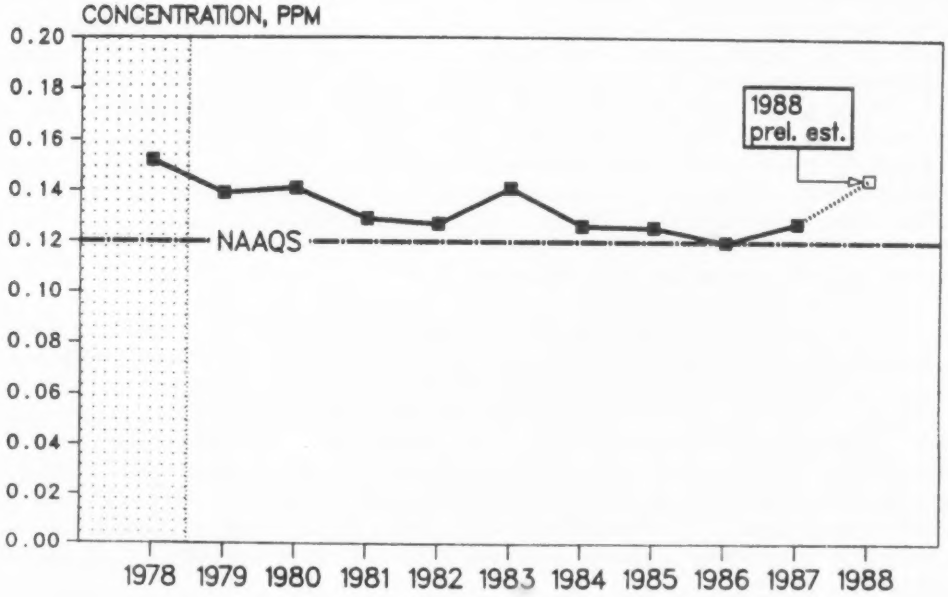


Figure 3-45. Preliminary estimate of the national trend in the composite average of the second highest daily maximum 1-hour ozone concentration, 1978-1988.

3.6 TRENDS IN LEAD

Lead (Pb) gasoline additives, nonferrous smelters and battery plants are the most significant contributors to atmospheric Pb emissions. Transportation sources in 1987 contributed 37 percent of the annual emissions, down substantially from 73 percent in 1985. Total lead emissions from all sources dropped from 21.1 x 10^3 metric tons in 1985 to 8.6 x 10^3 and 8.1 x 10^3 metric tons, respectively in 1986 and 1987. The decrease in lead emissions from highway vehicles accounts for essentially all of this drop. The reasons for this drop are noted below.

Two air pollution control programs implemented by EPA before promulgation of the Pb standard in October 1978[25] have resulted in lower ambient Pb levels. First, regulations issued in the early 1970s required gradual reduction of the Pb content of all gasoline over a period of many years. Most recently the Pb content of the leaded gasoline pool was reduced from an average of 1.0 grams/gallon to 0.5 grams/gallon on July 1, 1985 and still further to 0.1 grams/gallon on January 1, 1986. Second, as part of EPA's overall automotive emission control program, unleaded gasoline was introduced in 1975 for use in automobiles equipped with catalytic control devices. These devices reduce emissions of carbon monoxide, volatile organics and nitrogen oxides. In 1987 unleaded gasoline sales accounted for 76 percent of the total gasoline market. Additionally, Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the TSP and Pb ambient standards. Lead emissions in 1987 from industrial sources, e.g. primary and secondary lead smelters dropped by more than one-half from levels reported in the late 70s. Emissions of lead from solid waste disposal are down 35 percent since the late 70s. In 1987 emissions from solid waste disposal represent the second largest category of lead emissions. The overall effect of these three control programs has been a major reduction in the amount of Pb in the ambient air.

3.6.1 Long-term Pb Trends: 1978-87

Early trend analyses of ambient Pb data[26,27] were based almost exclusively on National Air Surveillance Network (NASN) sites. These sites were established in the 1960's to monitor ambient air quality levels of TSP and associated trace metals, including Pb. The sites were predominantly located in the central business districts of larger American cities. In September 1981, ambient Pb monitoring regulations were promulgated.[28] The siting criteria in the regulations resulted in finding many of the old historic TSP monitoring sites unsuitable for the measurement of ambient Pb concentrations.

As with the other pollutants, the sites selected for the long-term trend analysis had to satisfy annual data completeness criteria of at least 8 out of 10 years of data in the 1978 to 1987 period. A year was included as "valid" if at least 3 of the 4 quarterly averages were available. For the first time, composite lead data, i.e., individual 24-hour observations are composited together by month or quarter, and a single analysis made, are being used in the trend analysis. Nine sites qualified for the 10-year trend because of the addition of composite data. Sixty additional sites qualified for the 5-year trend, which will be discussed later. A total of only 97 urban-oriented sites, representing 27 states, met the data completeness criteria. Twenty-one of these sites were NAMS, the largest number of lead NAMS sites to qualify for the 10-year criteria. Thirty-five (36 percent) of the 97 trend sites were located in the States of California, Ohio and Pennsylvania; thus these States are over-represented in the sample of sites satisfying the long-term trend criteria. Sites that were located near lead point sources such as primary and secondary lead smelters were excluded from the urban trend analysis, because the magnitude of the levels at these sources could mask the underlying urban trends.

The means of the composite maximum quarterly averages and their respective 95 percent confidence intervals are shown in Figure 3-46 for both the 97 urban sites and 21 NAMS sites (1978-1987). There was an 88 percent (1978-87) decrease in the average for the 97 urban sites. The confidence intervals for these sites indicate that the 1978-80 averages are significantly different from the 1981-87 averages. Because of the smaller number (21) of NAMS sites with 8 years of data, the confidence intervals are wider. However, the 1986 and 1987 averages are still significantly different from all averages before 1985. It is interesting to note that the average lead concentrations at the NAMS sites in 1987 are only slightly higher than the "all sites" average; whereas in the late 70s the average of the NAMS sites was significantly higher. Figure 3-47 shows the trend in average lead concentrations for the urban-oriented sites and for 24 point-source oriented sites which met the 10-year data completeness criteria. The improvement in average ambient lead concentrations is even more pronounced at the point-source oriented sites, reflecting control improvements from automotive and, of course, industrial sources of lead. In some cases, the industrial source reductions are because of plant shutdowns. Figure 3-48 shows boxplot comparisons of the maximum quarterly average Pb concentrations at the 97 urban-oriented Pb trend sites (1978-87). This figure shows the dramatic improvement in ambient Pb concentrations for the entire distribution of trend sites. As with the composite average concentration since 1978, most of the percentiles also show a monotonically decreasing pattern. The 97 urban-oriented sites that qualified for the 1978-87 period, when compared to the 82 sites for the 1977-86 period in last year's report,[17] indicate the expansion of the data base in more recent years.

The trend in total lead emissions is shown in Figure 3-49. Table 3-6 summarizes the Pb emissions data as well. The 1978-87 drop in total Pb emissions was 94 percent. This compares with a 88 percent decrease (1978-87) in ambient Pb noted above. The drop in Pb consumption and subsequent Pb emissions since 1978 was brought about by the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline as noted above. The results of these actions in 1987 amounted to a 62 percent reduction nationwide in total Pb emissions from 1985 levels. As noted above, unleaded gasoline represented 76 percent of 1987 total gasoline sales. Although the good agreement among the trend in lead consumption, emissions and ambient levels is based upon a limited geographical sample, it does show that ambient urban Pb levels are responding to the drop in lead emissions.

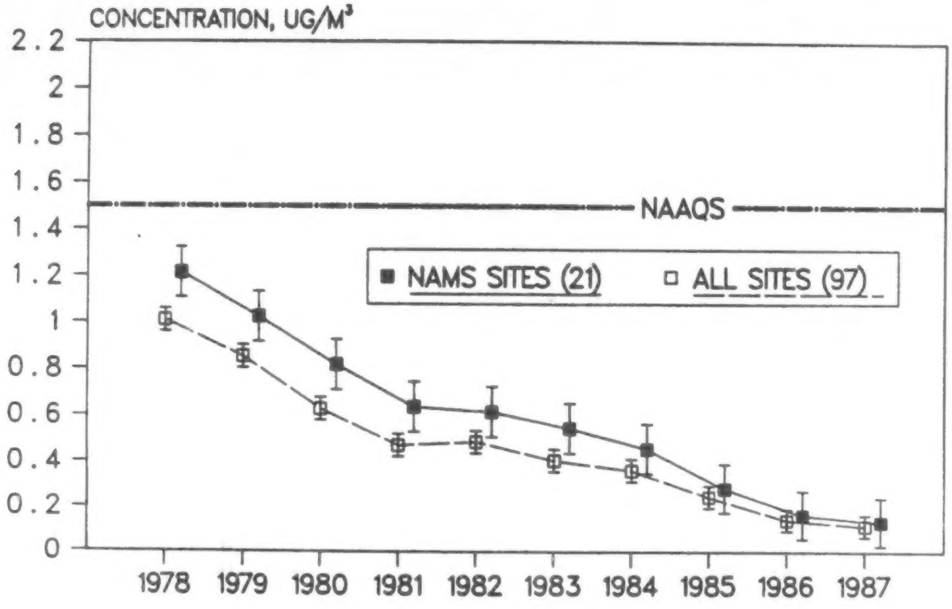


Figure 3-46. **National trend in the composite average of the maximum quarterly average lead concentration at 97 sites and 21 NAMS sites with 95 percent confidence intervals, 1978-1987.**

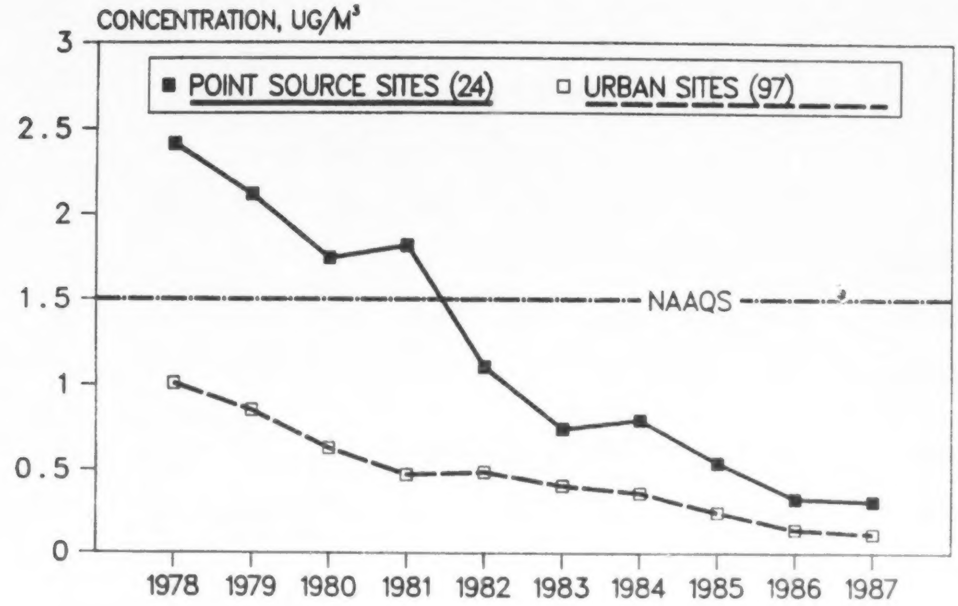


Figure 3-47. Comparison of national trend in the composite average of the maximum quarterly average lead concentrations at urban and point-source oriented sites, 1978-1987.

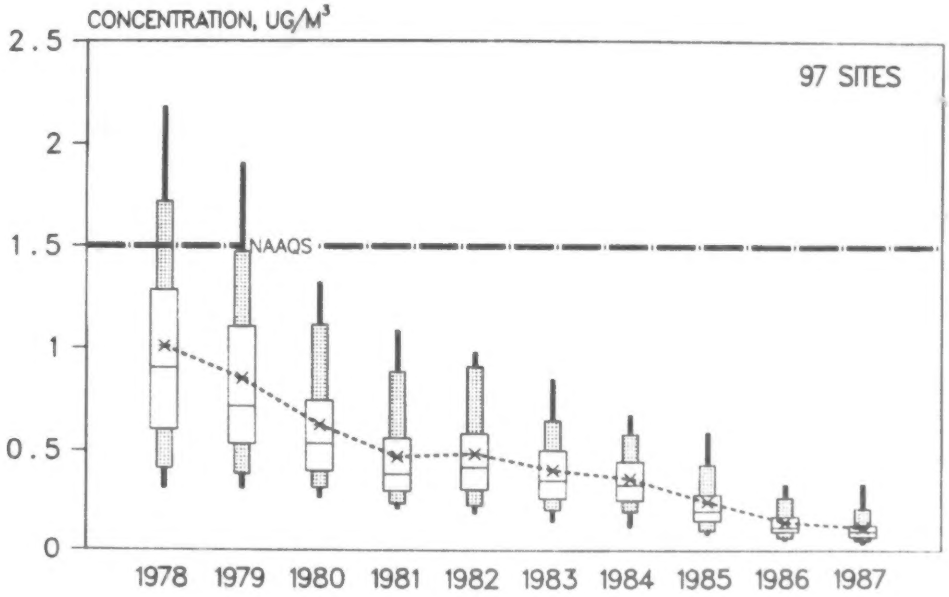


Figure 3-48. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 97 sites, 1978-1987.

Table 3-6. National Lead Emission Estimates, 1978-1987.

(thousand metric tons/year)

Source Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Transportation	112.4	94.6	59.4	46.4	46.9	40.7	34.7	15.5	3.5	3.0
Fuel Combustion	6.1	4.9	3.9	2.8	1.7	0.6	0.5	0.5	0.5	0.5
Industrial Processes	5.4	5.2	3.6	3.0	2.7	2.4	2.3	2.3	1.9	2.0
Solid Waste	4.0	4.0	3.7	3.7	3.1	2.6	2.6	2.8	2.7	2.6
Total	127.9	108.7	70.6	55.9	54.4	46.3	40.1	21.1	8.6	8.1

NOTE: The sums of sub-categories may not equal total due to rounding.

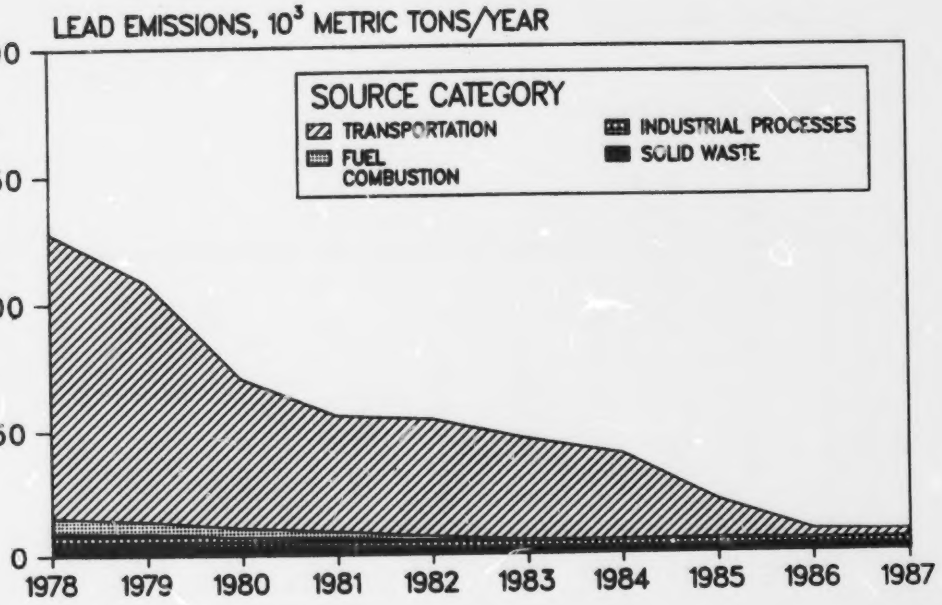


Figure 3-49. National trend in lead emissions, 1978-1987.

3.6.2 Recent Pb Trends: 1983-87

Ambient Pb trends were also studied over the shorter period 1983-87 (Figure 3-50). A total of 394 urban sites in 44 states met the minimum data requirement of at least 4 out of the 5 years of data. This larger and more representative set of sites showed an improvement of 71 percent in average Pb concentrations during this time period. This corresponds to reductions in total Pb emissions of 83 percent. Most of this decrease in total nationwide Pb emissions, 99 percent, was due to the decrease in automotive Pb emissions. Even this larger group of sites was disproportionately weighted by sites in California, Illinois, Pennsylvania, and Texas. These states had 35 percent of the 394 sites represented. However, the percent changes in 1983-87 average Pb concentrations for these four states were very similar to the percent change at all sites, thus these contributions of the sites did not bias the national trends. Indeed, as will be shown later, all sections of the country are showing declines in average lead concentrations. It is worth noting that the sites in the 10-year data base also showed a 71 percent decrease during this 5-year period, suggesting that, despite the geographical imbalance, their patterns may adequately depict national trends.

Because of the much larger sample of sites represented in the 5-year trends (1983-87), compared with the 10-year, the larger sample will be used to compare individual yearly averages. The largest single year drop in average lead concentrations, 42 percent, occurs as expected between 1985 and 1986, because of the shift from 1.0 grams/gallon of lead in leaded gasoline for the first half of 1985 to 0.5 grams/gallon of lead in July 1985, and finally to 0.1 grams of lead/gallon on January 1, 1986. However, 1987 average lead concentrations show the more modest decline of 19 percent from 1986 levels. This trend is expected to continue primarily because the leaded gasoline market will continue to shrink. Some major petroleum companies have discontinued refining leaded gasoline because of the dwindling market, so that in the future the consumer may find it more difficult to purchase regular leaded gasoline.

Figure 3-51 shows 1985, 1986 and 1987 composite average Pb concentrations, by EPA Region. Once again the larger more representative 5-year data base of 394 sites was used for comparison. The number of sites varies dramatically by Region from 2 in Region X to 82 in Region V. In all Regions, there is a substantial difference in average Pb concentrations between 1985 and 1987. These results confirm that average Pb concentrations in urban areas are continuing to decrease in all sections of the country, which is exactly what is to be expected because of the national air pollution control program for Pb.

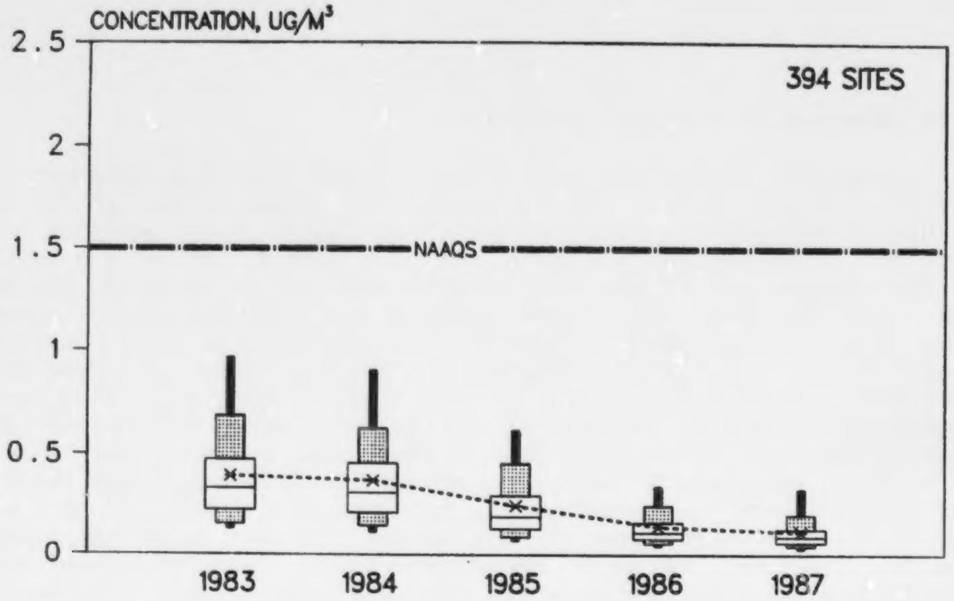


Figure 3-50. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 394 sites, 1978-1987.

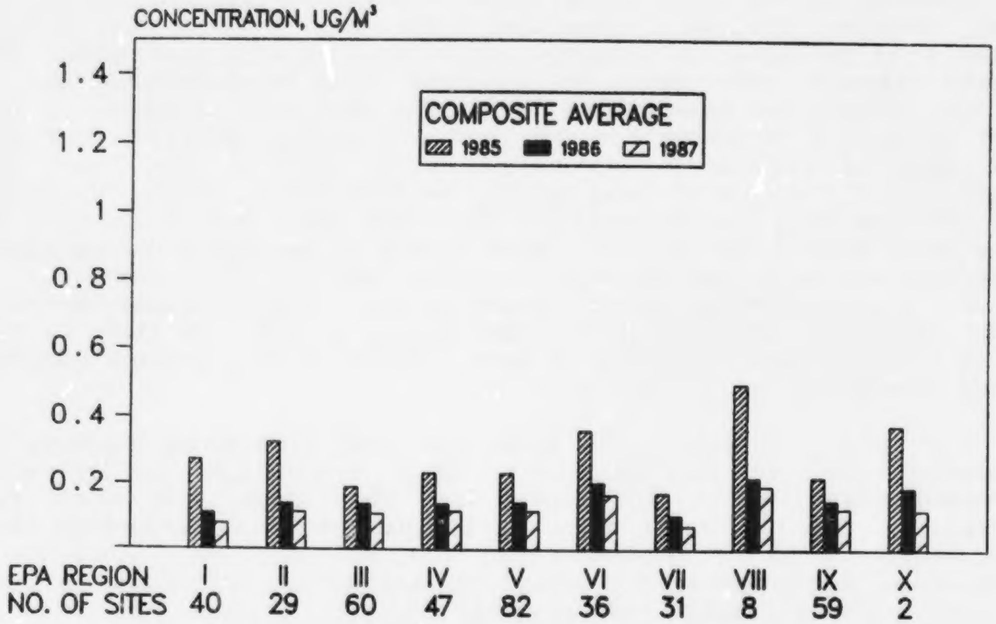


Figure 3-51. Regional comparison of the 1985, 1986, 1987 composite average of the maximum quarterly average lead concentration.

3.7 REFERENCES

1. J. W. Tukey, Exploratory Data Analysis, Addison-Wesley Publishing Company, Reading, MA, 1977.

2. B. J. Winer, Statistical Principles in Experimental Design, McGraw-Hill, NY, 1971.

3. N. L. Johnson and S. Kotz, Discrete Distributions, Wiley, NY, 1969.

4. R. G. Miller, Jr., Simultaneous Statistical Inference, Springer-Verlag, NY, 1981.

5. A. Pollack, W. F. Hunt, Jr., and T. C. Curran, "Analysis of Variance Applied to National Ozone Air Quality Trends", presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA, June 1984.

6. A. Pollack and W. Hunt, "Analysis of Trends and Variability in Extreme and Annual Average Sulfur Dioxide Concentrations", presented at the Air Pollution Control Association, American Society for Quality Control Specialty Conference on Quality Assurance in Air Pollution Measurement, Boulder, CO, 1985.

7. National Air Quality and Emissions Trends Report, 1984, EPA-450/4-86-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, April 1986.

8. National Air Pollutant Emission Estimates, 1940-1987, EPA-450/4-88-022, U. S. Environmental Protection Agency. Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1989.

9. National Air Quality and Emissions Trends Report, 1983, EPA-450/4-84-029, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, April 1985.

10. National Air Quality and Emissions Trends Report, 1985, EPA-450/4-87-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1987.

11. N. H. Frank, "Nationwide Trends in Total Suspended Particulate Matter and Associated Changes in the Measurement Process", presented at the Air Pollution Control Association, American Society for Quality Control Specialty Conference on Quality Assurance in Air Pollution Measurement, Boulder, CO, October 1984.

12. Written communication from Thomas R. Hauser, Environmental Monitoring Systems Laboratory, U. S. Environmental Protection Agency, Research Triangle Park, NC, to Richard G. Rhoads, Monitoring and Data Analysis Division, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 11, 1984.

13. J. Steigerwald, "1987 Total Precipitation Trends Versus 1986 Levels, 5 year Average levels, and Long Term Average Levels", EPA Contract No. 68-02-4390, PEI Associates, Inc., Durham, NC, November 30, 1988.

14. 1985 NEDS Data Base, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1986.

15. W. M. Koerber, "Trends in SO2 Emissions and Associated Release Height for Ohio River Valley Power Plants", presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA, June 1982.

16. Written Communication from C. Bergesen, Utility Data Institute, Inc., to F. William Brownell, Esq., Hunton and Williams, Washington, DC, February 21, 1985.

17. National Air Quality and Emissions Trends Report, 1986, EPA-450/4-88-001, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1988.

18. Measurement of Ozone in the Atmosphere, 43 FR 26971, June 22, 1978.

19. Use of Meteorological Data in Air Quality Trend Analysis, EPA-450/3-78-024, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1978.

20. J. Steigerwald, "Using Publicly Reported Air Quality Index Data to Provide Updated Trends Information: 1987 Data Compilations", EPA Contract No. 68-02-4390, PEI Associates, Inc., Durham, NC, March 1988.

21. ARC/INFO, Environmental Systems Research Institute, Redlands, CA.

22. Written communication from Thomas Furmanczyk, Environment Canada, Quebec, Canada to Terence Fitz-Simons, Technical Support Division, U. S. Environmental Protection Agency, Research Triangle Park, NC, November 16, 1988.

23. New York Times, July 31, 1988.

24. USA Today, September 6, 1988.

25. National Primary and Secondary Ambient Air Quality Standards for Lead, 43 FR 46246, October 5, 1978.

26. R. B. Faoro and T. B. McMullen, National Trends in Trace Metals Ambient Air, 1965-1974, EPA-450/1-77-003, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1977.

27. W. Hunt, "Experimental Design in Air Quality Management," Andrews Memorial Technical Supplement, American Society for Quality Control, Milwaukee, WI, 1984.

28. Ambient Air Quality Surveillance, 46 FR 44159, September 3, 1981.

4. AIR QUALITY LEVELS IN METROPOLITAN STATISTICAL AREAS

This section summarizes 1987 air quality levels for each Metropolitan Statistical Area (MSA) in the United States. Previous reports have presented air quality data only for those large MSAs with populations greater than 500,000. This section has been expanded this year to provide more extensive air quality information for general air pollution audiences.

The general concept of a metropolitan area is one of a large population center, with adjacent communities which have a high degree of economic and social integration with the urban center. Metropolitan Statistical Areas contain a central county(ies), and any adjacent counties with at least 50 percent of their population in the urbanized area.[1] Figure 4-1 illustrates that, although MSAs compose only 16 percent of the land area in the U.S., they account for 77 percent of the population. Table 4-1 displays the population distribution of the 338 MSAs, based on 1986 population estimates.[1]

These summaries are complemented with an estimate of the number of people living in counties in which pollutant-specific primary health NAAQS were exceeded by measured air quality in 1987. These estimates use a single-year interpretation of the NAAQS. Table 4-2 lists the selected air quality statistics and their associated NAAQS. Figure 4-2 clearly demonstrates that O_3 is the most pervasive air pollution problem in 1987 for the United States with an estimated 88.6 million people living in counties which exceeded the O_3 standard. Carbon monoxide follows, with 29.4 million people; PM_{10} with 21.5 million people; NO_2 with 7.5 million people; Pb with 2.8 million people; and SO_2 with 1.6 million people. A total of 102 million persons reside in counties exceeding at least one air quality standard during 1987. These estimates are based on available 1980 county population data, thus, the 7 percent growth in total U.S. population since 1980 is not reflected in these county estimates. Also, the estimate for PM_{10} is considered a lower bound estimate, because the PM_{10} monitoring network is still evolving and the required sampling schedules are being determined.

These population estimates are intended to provide a relative measure of the extent of the effect of each pollutant. The limitations of this indicator should be recognized. An individual living in a county that violates an air quality standard may not actually be exposed to unhealthy air. For example, if CO violations were confined to a traffic-congested center city during evening rush hours in the winter, it is possible that an individual may never be in that area, or may be there only at other times of the day or during other seasons. However, it is worth noting that ozone, which appears to be the most pervasive pollution problem by this measure, is also the pollutant most likely to have fairly uniform concentrations throughout an area.

In the MSA summary table which follows, the air quality statistics relate to selected pollutant-specific NAAQS listed in Table 4-2. The population data for each MSA are the 1986 population estimates available from the Bureau of the Census.[1] This summary provides the reader with information on how air quality varied among the nation's metropolitan areas in 1987. The highest air quality levels measured in each MSA are summarized for each pollutant monitored in 1987. Individual MSAs are listed to provide more extensive spatial coverage for large metropolitan complexes.

The reader is cautioned that this summary is not adequate in itself to rank or to compare the MSAs according to their air quality. To rank properly the air pollution severity in different MSAs, data on population characteristics, daily population mobility, transportation patterns, industrial composition, emission inventories, meteorological factors and, most important, the spatial representativeness of the monitoring sites would also be needed.

The same annual data completeness criteria used in the air quality trends data base was used here for the calculation of annual means. (i.e., 50 percent of the required samples). If some data have been collected at one or more sites, but none of these sites meet the annual data completeness criteria, then the reader will be advised that there are insufficient data to calculate the annual mean.

In contrast to the trends analyses in Sections 3 and 5 which used a more relaxed indicator, only maximum quarterly average Pb concentrations meeting the AIRS validity criteria of 12 observations per quarter are displayed in Table 4-3. With respect to the summary statistics on air quality levels with averaging times less than or equal to 24-hours, all sites are included, even if they do not meet the annual data completeness requirement.

TABLE 4-1. Population Distribution of Metropolitan Statistical Areas Based on 1986 Population Estimates

Population Range	Number of MSAs	Total Population
≤ 100,000	27	2,269,000
100,000 < population ≤ 250,000	146	23,142,000
250,000 < population ≤ 500,000	75	25,914,000
500,000 < population ≤ 1,000,000	46	32,972,000
1,000,000 < population ≤ 2,000,000	26	38,164,000
population > 2,000,000	18	64,838,000
Totals	338	187,299,000

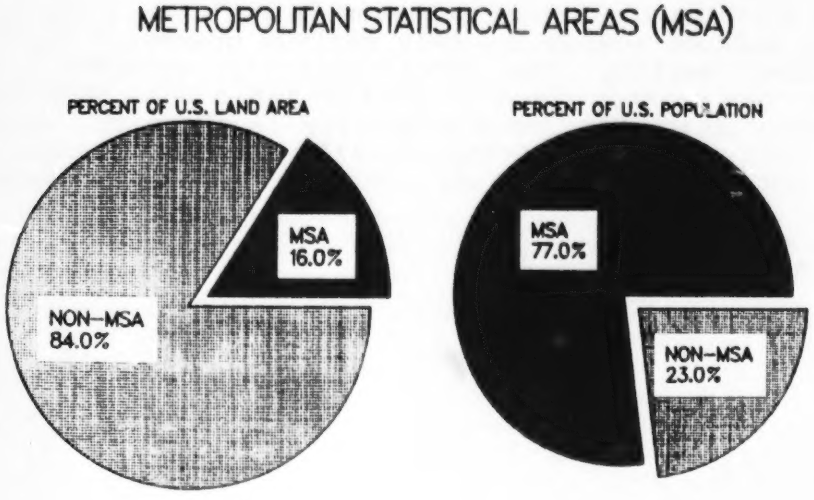


Figure 4-1. Percent of U.S. population and land area within MSAs, 1986.

Table 4-2. Selected Air Quality Summary Statistics and Their Associated National Ambient Air Quality Standards (NAAQS)*

POLLUTANT	STATISTICS	PRIMARY NAAQS
Particulate Matter (PM_{10})	annual arithmetic mean	50 ug/m^3
Sulfur Dioxide (SO_2)	annual arithmetic mean	0.03 ppm
	second highest 24-hour average	0.14 ppm
Carbon Monoxide (CO)	second highest nonoverlapping 8-hour average	9 ppm
Nitrogen Dioxide (NO_2)	annual arithmetic mean	0.053 ppm
Ozone (O_3)	second highest daily maximum 1-hour average	0.12 ppm
Lead (Pb)	maximum quarterly average	1.5 ug/m^3

μg/m^3 = micrograms per cubic meter ppm = parts per million

*Single year interpretation. For a detailed listing of the NAAQS see Table 2-1.

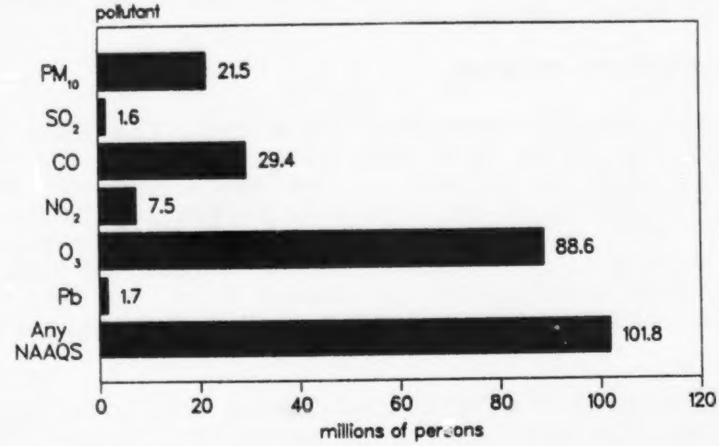


Figure 4-2. Number of persons living in counties with air quality levels above the primary national ambient air quality standards in 1987 (based on 1980 population data).

4.1 SUMMARY STATISTICS

In Table 4-3, the air quality levels reported for each metropolitan area are the highest levels measured from all available sites within the MSA. In the case of O_3, the problem is pervasive, and the high values associated with the pollutant can reflect a large part of the MSA. However in many cases, peak ozone concentrations occur downwind of major urban areas, e.g., peak ozone levels attributed to the Chicago metropolitan area are recorded in and near Racine, Wisconsin. In contrast, high CO values generally are highly localized and reflect areas with heavy traffic. The scale of measurement for the pollutants - PM_{10}, SO_2 and NO_2 - falls somewhere in between. Finally, while Pb measurements generally reflect Pb concentrations near roadways in the MSA, if a monitor is located near a point source of lead emissions it can produce readings substantially higher. Such is the case in several MSAs. Pb monitors located near a point source are footnoted accordingly in Table 4-3.

The pollutant-specific statistics reported in this Section are summarized in Table 4-2, with their associated primary NAAQS concentrations for a single year of data. For example, if an MSA has three ozone monitors in 1987 with second highest daily hourly maxima of .15 ppm, .14 ppm and .12 ppm, the highest of these, .15 ppm, would be reported for that MSA for 1987.

In the case of Pb, the quarterly average is based on either up to 90 24-hour measurements or one or more chemical composite measurements."[1] Most of the maximum quarterly Pb averages are based on multiple 24-hour measurements.

4.2 MSA AIR QUALITY SUMMARY

In the air quality summary, Table 4-3, the MSAs are listed alphabetically, with the 1986 population estimate and air quality statistics for each pollutant. The New York, NY MSA is the nation's largest metropolitan area with a 1986 population in excess of 8 million. The smallest MSA is Enid, OK with a population of 63,000. The population groupings and the number of MSAs contained within each range are listed in Table 4-1. The MSA population statistics are based on the 1986 Metropolitan Statistical Area estimates.[1]

Air quality maps of the United States are introduced to show at a glance how air quality varies among the largest MSAs within the contiguous United States. To enable the reader to distinguish individual urban areas, only the 88 MSAs within the continental

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[1] A chemical composite measurement can be either a measurement for an entire month or an entire quarter.

U.S. having populations greater than 500,000 are shown. Two large MSAs, Honolulu, HI and San Juan, PR are not shown. Figures 4-3 through 4-9 appear just before the table summarizing the air pollution statistics. In each map, a spike is plotted at the city location on the map surface. This represents the highest pollutant concentration recorded in 1987, corresponding to the appropriate air quality standard. Each spike is projected onto a back-drop for comparison with the level of the standard. The backdrop also provides an east-west profile of concentration variability throughout the country.

The map for PM$_{10}$ shows the 1987 maximum annual arithmetic means in metropolitan areas greater than 500,000 population. Concentrations above the level of the PM$_{10}$ standard of 50 ug/m^3 are found in eleven of these metropolitan areas (Figure 4-3).

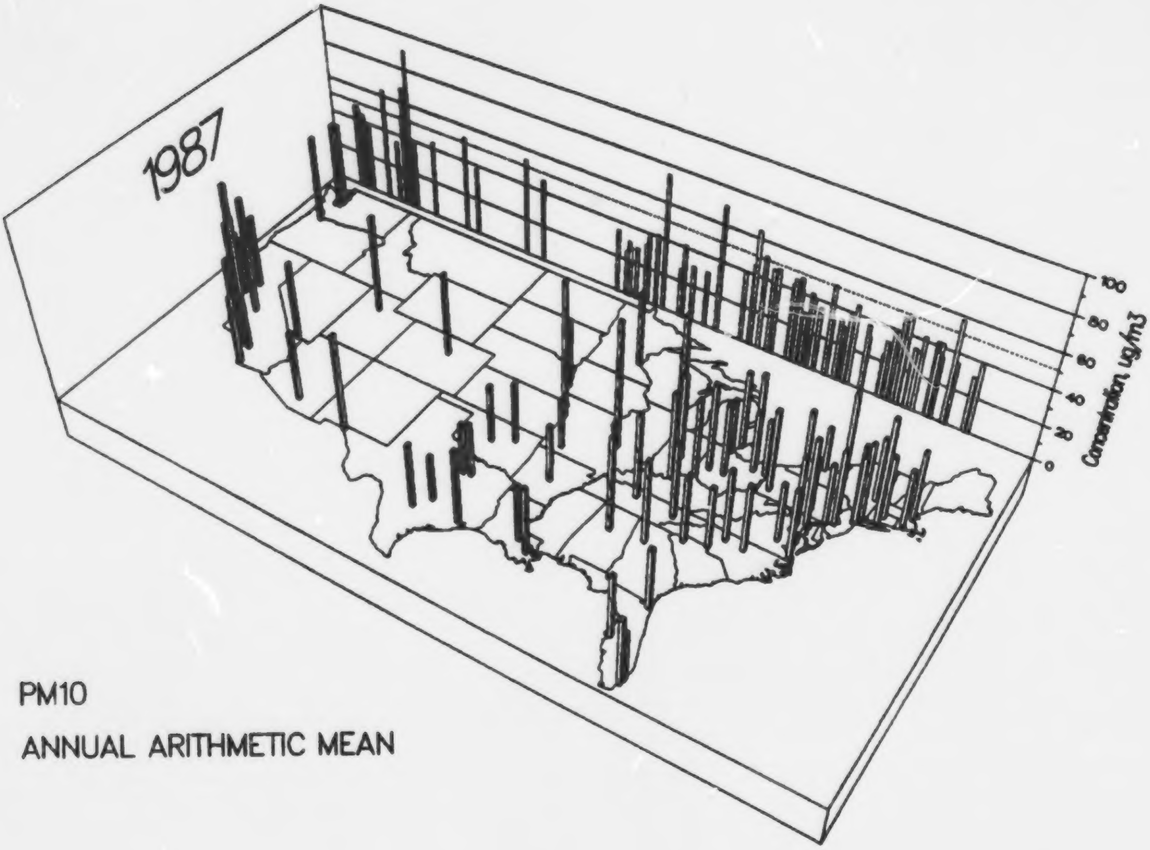
1987
0
20
40
60
80
100
Concentration, ug/m3
PM10
ANNUAL ARITHMETIC MEAN

Figure 4-3. United States map of the highest annual arithmetic mean PM$_{10}$ concentration by MSA, 1987.

The map for sulfur dioxide shows maximum annual mean concentrations in 1987. Among these large metropolitan areas, the higher concentrations are found in the heavily populated Midwest and Northeast. All these large urban areas have ambient air quality concentrations lower than the current annual standard of 80 ug/m3 (.03 ppm). Because this map only represents areas with population greater than one half million, it does not reflect air quality in the vicinity of smelters or large power plants in rural areas (Figure 4-4).

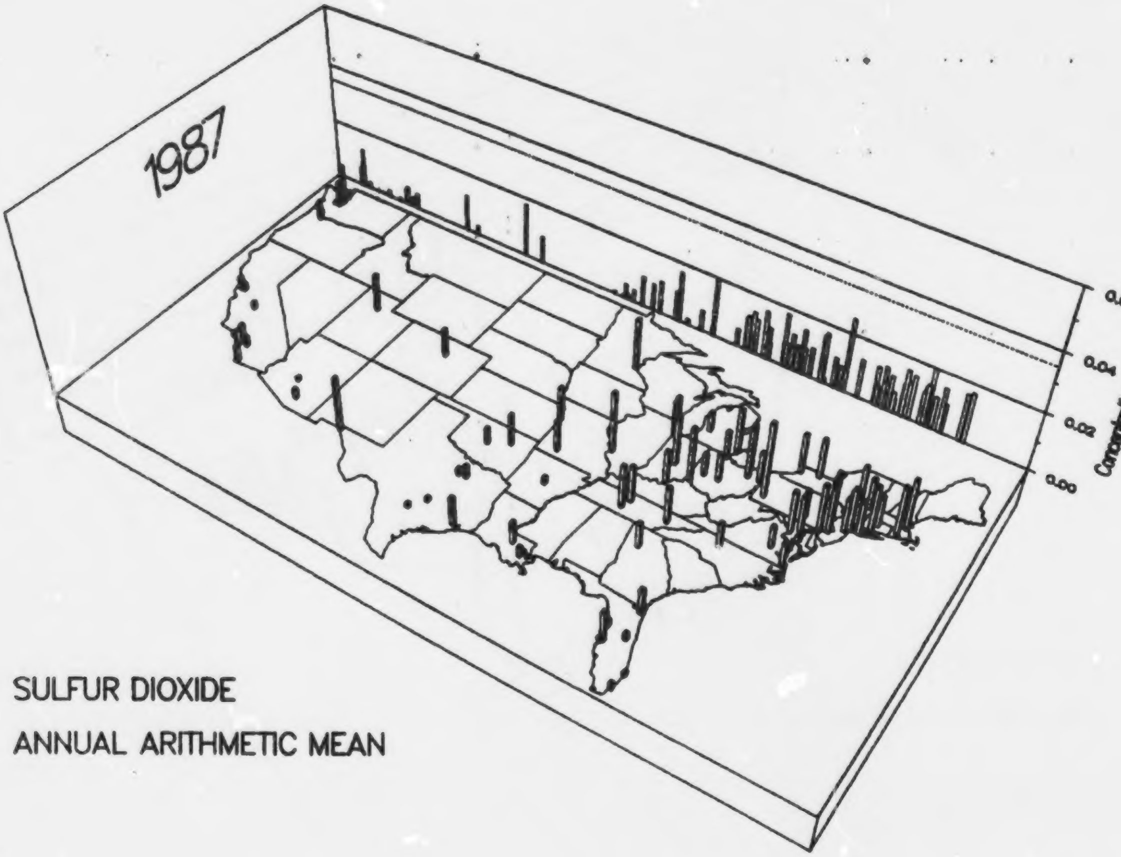
1987
0.06
0.04
0.02
0.00
Concentration, ppm
SULFUR DIOXIDE
ANNUAL ARITHMETIC MEAN

Figure 4-4. **United States map of the highest annual arithmetic mean sulfur dioxide concentration by MSA, 1987.**

The map for sulfur dioxide shows the highest second highest maximum 24-hour average sulfur dioxide concentration by MSA in 1987. The highest concentration in a large urban area is found at a site in Pittsburgh, PA which is impacted by major SO_2 sources. All other major urban areas have ambient concentrations below the 24-hour NAAQS of 0.14 parts per million (Figure 4-5).

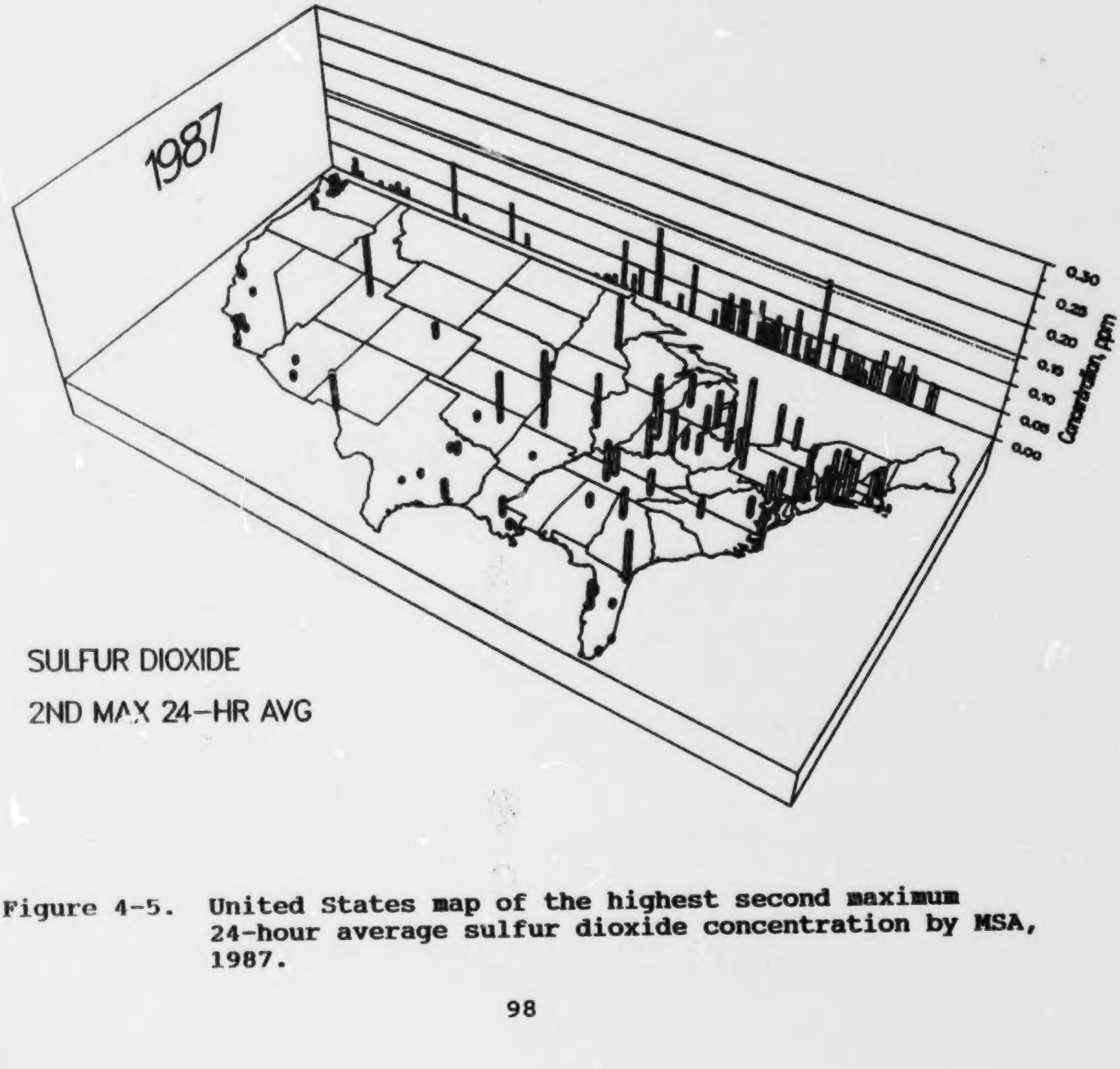
1987
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration, ppm
SULFUR DIOXIDE
2ND MAX 24-HR AVG

Figure 4-5. **United States map of the highest second maximum 24-hour average sulfur dioxide concentration by MSA, 1987.**

The map for carbon monoxide shows peak metropolitan are concentrations in terms of the second highest annual 8-hour value recorded in 1987. The east-west profile indicates that about a third of these urban areas in all geographic regions have air quality at or exceeding the 9 ppm level of the standard. While highest concentration recorded in 1987 is found in New York, NY, twenty-one of these large metropolitan areas exceeded the 8-hour CO NAAQS in 1987 (Figure 4-6).

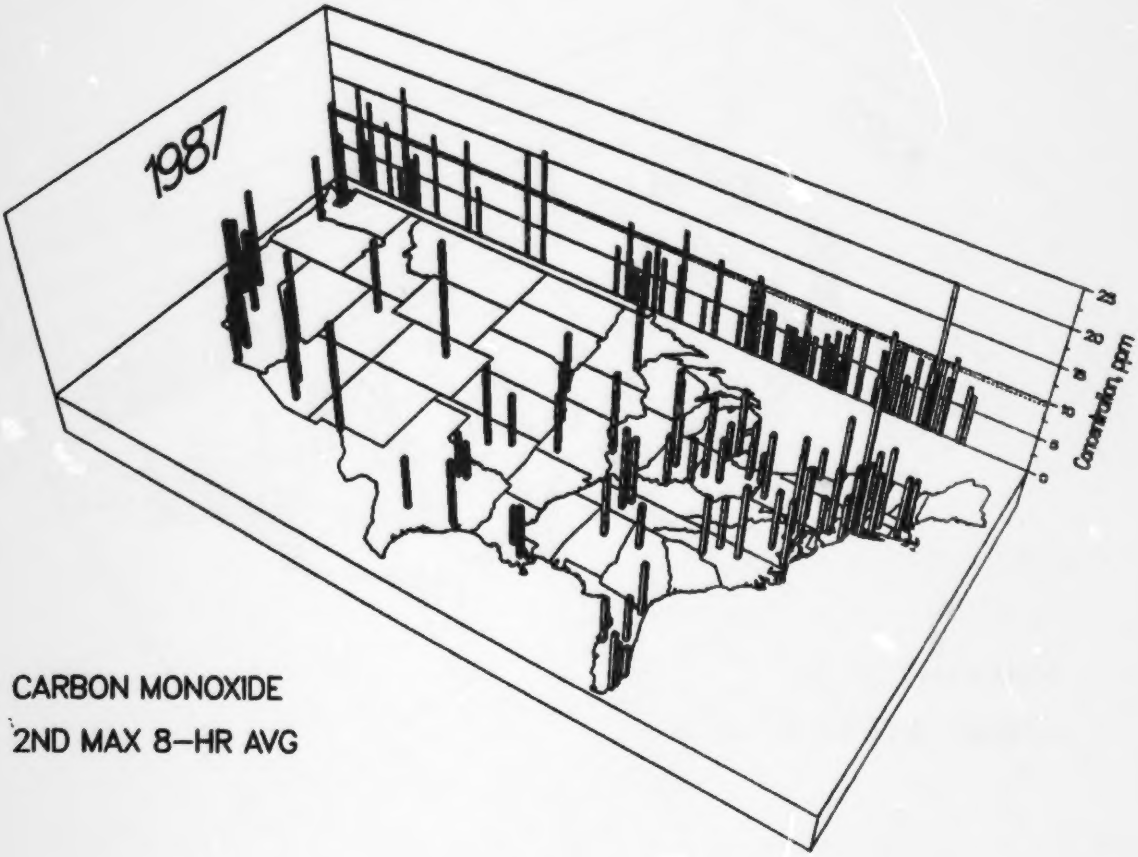
1987
0
5
10
15
20
25
Concentration, ppm
CARBON MONOXIDE
2ND MAX 8—HR AVG

Figure 4-6. United States map of the highest second maximum nonoverlapping 8-hour average carbon monoxide concentration by MSA, 1987.

The map for nitrogen dioxide displays the maximum annual mean measured in the nation's largest metropolitan areas during 1987. Los Angeles, California, with an annual NO_2 mean of 0.055 ppm is the only area in the country exceeding the NO_2 air quality standard of .053 ppm (Figure 4-7).

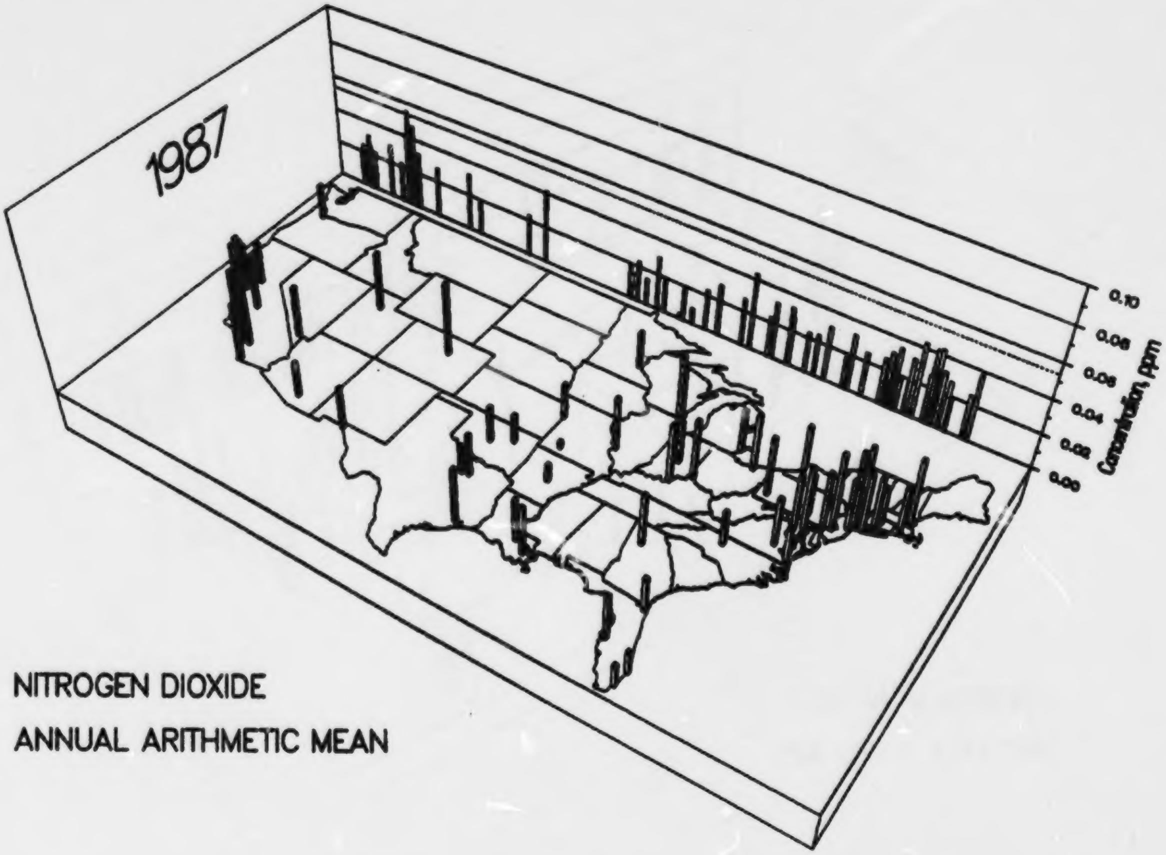
1987
0.10
0.08
0.06
0.04
0.02
0.00
Concentration, ppm
NITROGEN DIOXIDE
ANNUAL ARITHMETIC MEAN

Figure 4-7. United States map of the highest annual arithmetic mean nitrogen dioxide concentration by MSA, 1987.

The ozone map shows the second highest daily maximum 1-hour concentration in the 88 largest metropolitan areas in the Continental U.S. As shown, about 60 percent of these areas (52 MSAs) did not meet the 0.12 ppm standard in 1987. The highest concentrations are observed in Southern California, but high levels also persist in the Texas Gulf Coast, Northeast Corridor, and other heavily populated regions (Figure 4-8).

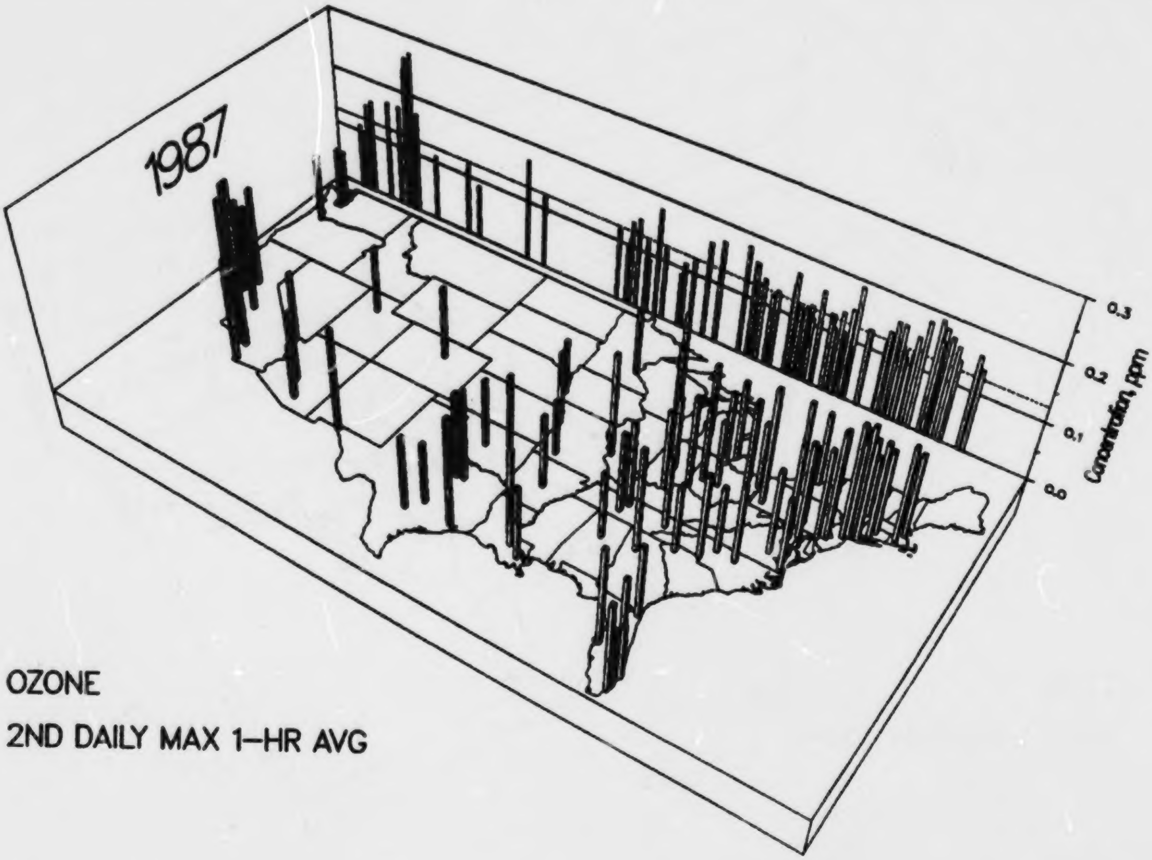

Figure 4-8. United States map of the highest second daily maximum 1-hour average ozone concentration by MSA, 1987.

The map for Pb displays maximum quarterly average concentrations in the nation's largest metropolitan areas. Exceedances of the Pb NAAQS are found in the vicinity of nonferrous smelters or other point sources of lead in three large cities. Because of the switch to unleaded gasoline, other areas, primarily affected by automotive lead emissions, show levels below the current standard of 1.5 ug/m$_3$ (Figure 4-9).

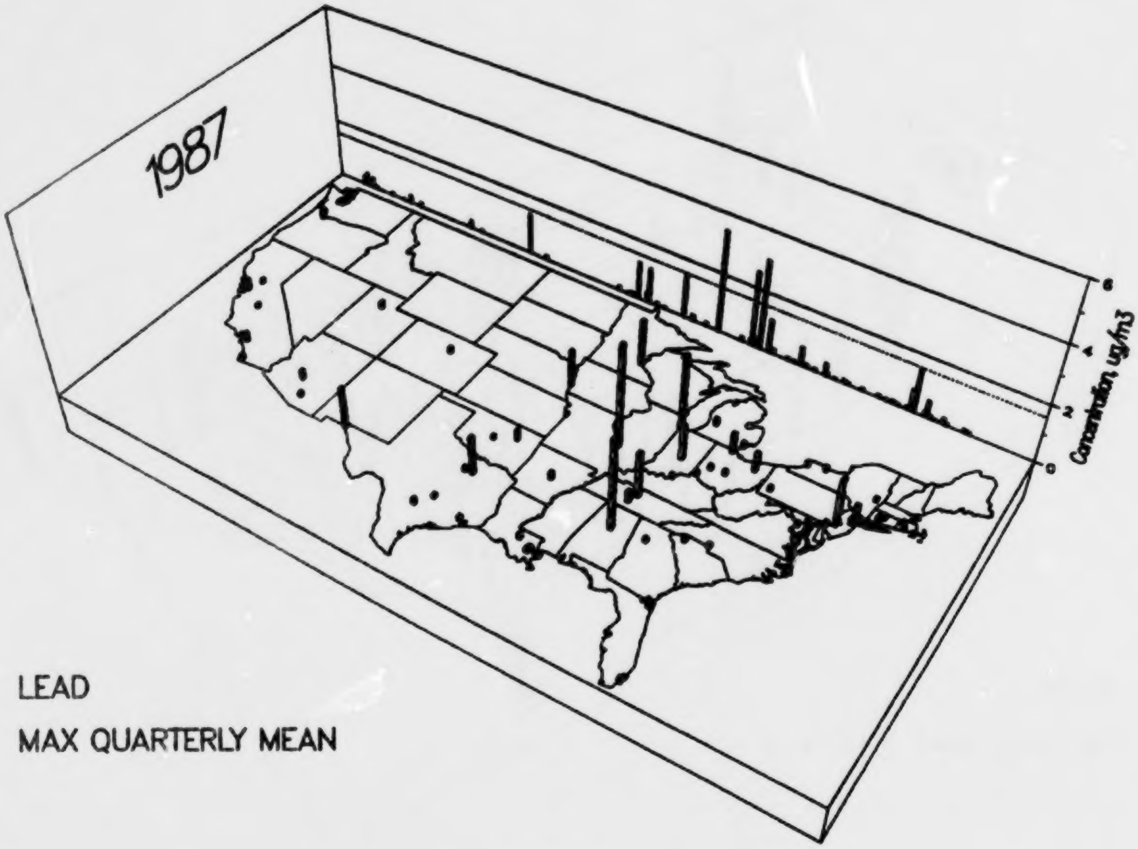

Figure 4-9. **United States map of the highest maximum quarterly average lead concentration by MSA, 1987.**

4.3 REFERENCES

1. Statistical Abstract of the United States, 1988, U. S. Department of Commerce, U. S. Bureau of the Census, Appendix II.

TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
ABILENE, TX	126,000	ND	ND	ND	ND	ND	ND	ND
AGUADILLA, PR	156,000	ND	ND	ND	ND	ND	ND	ND
AKRON, OH	645,000	33	0.017	0.057	5	ND	0.13	0.16
ALBANY, GA	117,000	ND	ND	ND	ND	ND	ND	ND
ALBANY-SCHENECTADY-TROY, NY	844,000	34	0.010	0.047	8	ND	0.10	0.08
ALBUQUERQUE, NM	474,000	33	ND	ND	16	0.018	0.10	0.10
ALEXANDRIA, LA	140,000	ND	ND	ND	ND	ND	ND	ND
ALLENTOWN-BETHLEHEM, PA-NJ	657,000	33	0.012	0.035	5	0.019	0.13	0.76
ALTOONA, PA	132,000	29	0.010	0.051	ND	ND	0.13	ND
AMARILLO, TX	195,000	18	ND	ND	ND	ND	ND	0.03
ANAHEIM-SANTA ANA, CA	2,167,000	50	0.005	0.015	10	0.042	0.24	ND
ANCHORAGE, AK	235,000	31	ND	ND	12	ND	ND	0.18
ANDERSON, IN	133,000	ND	ND	ND	ND	ND	ND	ND
ANDERSON, SC	141,000	ND	ND	ND	ND	ND	ND	0.06
ANN ARBOR, MI	266,000	ND	0.007	0.065	ND	ND	0.11	ND
ANNISTON, AL	124,000	ND	ND	ND	ND	ND	ND	ND
APPLETON-OSHKOSH-NEENAH, WI	307,000	ND	IN	0.036	ND	ND	0.10	ND
ARECIBO, PR	170,000	ND	ND	ND	ND	ND	ND	ND
ASHEVILLE, NC	170,000	31	ND	ND	ND	ND	0.09	ND
ATHENS, GA	141,000	ND	ND	ND	ND	ND	ND	ND
ATLANTA, GA	2,561,000	46	0.008	0.050	6	0.028	0.17	0.08
ATLANTIC CITY, NJ	297,000	44	0.004	0.016	ND	ND	0.14	0.06
AUGUSTA, GA-SC	390,000	23	ND	ND	ND	ND	ND	0.03
AURORA-ELGIN, IL	343,000	ND	ND	ND	ND	ND	0.10	0.11
AUSTIN, TX	726,000	25	0.001	0.009	ND	ND	0.10	0.08
BAKERSFIELD, CA	494,000	64	0.006	0.016	7	0.029	0.16	0.13
BALTIMORE, MD	2,280,000	48	0.012	0.045	9	0.035	0.17	0.13
BANGOR, ME	83,000	IN	IN	0.037	ND	ND	ND	0.07
BATON ROUGE, LA	546,000	31	0.007	0.030	5	0.023	0.16	0.14
BATTLE CREEK, MI	137,000	33	ND	ND	ND	ND	ND	ND
BEAUMONT-PORT ARTHUR, TX	376,000	ND	0.010	0.058	4	IN	0.13	0.04
BEAVER COUNTY, PA	193,000	ND	0.012	0.050	3	0.021	0.11	0.24
BELLINGHAM, WA	114,000	45	0.008	0.025	ND	ND	ND	ND
BENTON HARBOR, MI	164,000	ND	ND	ND	ND	ND	ND	ND
BERGEN-PASSAIC, NJ	1,298,000	42	0.011	0.038	8	0.036	0.17	0.13

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
BILLINGS, MT	120,000	IN	0.024	0.099	ND	ND	ND	ND
BILOXI-GULFPORT, MS	204,000	ND	0.007	0.045	ND	ND	ND	ND
BINGHAMTON, NY	262,000	ND	ND	ND	ND	ND	ND	ND
BIRMINGHAM, AL	911,000	52	IN	0.018	6	ND	0.14	3.04 (1)
BISMARK, ND	86,000	23	ND	ND	ND	ND	ND	ND
BLOOMINGTON, IN	102,000	ND	ND	ND	ND	ND	ND	0.03
BLOOMINGTON-NORMAL, IL	123,000	ND	ND	ND	ND	ND	ND	ND
BOISE CITY, ID	194,000	48	ND	ND	8	ND	ND	0.16
BOSTON, MA	2,824,000	39	0.017	0.049	7	0.038	0.14	0.12
BOULDER-LONGMONT, CO	214,000	40	ND	ND	9	ND	0.12	ND
BRADENTON, FL	177,000	ND	ND	ND	ND	ND	ND	ND
BRAZORIA, TX	189,000	ND	ND	ND	ND	ND	ND	ND
BREMERTON, WA	169,000	ND	ND	ND	9	ND	ND	ND
BRIDGEPORT-MILFORD, CT	444,000	31	0.013	0.045	5	0.026	0.17	0.13
BRISTOL, CT	76,000	ND	ND	ND	ND	ND	ND	0.06
BROCKTON, MA	188,000	ND	ND	ND	ND	ND	0.12	ND
BROWNSVILLE-HARLINGEN, TX	257,000	ND	ND	ND	ND	ND	ND	0.04
BRYAN-COLLEGE STATION, TX	121,000	ND	ND	ND	ND	ND	ND	ND
BUFFALO, NY	965,000	31	0.013	0.068	5	0.025	0.13	0.11
BURLINGTON, NC	102,000	ND	ND	ND	ND	ND	ND	ND
BURLINGTON, VT	125,000	30	0.006	0.018	5	0.019	0.09	ND
CAGUAS, PR	275,000	ND	ND	ND	ND	ND	ND	ND
CANTON, OH	400,000	ND	0.010	0.045	4	ND	0.12	ND
CASPER, WY	71,000	29	ND	ND	ND	ND	ND	ND
CEDAR RAPIDS, IA	169,000	39	0.010	0.071	3	0.025	0.10	ND
CHAMPAIGN-URBANA-RANTOUL, IL	171,000	ND	0.005	0.021	ND	ND	0.10	ND
CHARLESTON, SC	486,000	30	0.005	0.042	5	ND	0.10	0.05
CHARLESTON, WV	266,000	37	0.009	0.035	5	0.021	0.11	0.06
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	1,065,000	34	ND	ND	8	ND	0.14	0.07
CHARLOTTESVILLE, VA	121,000	ND	ND	ND	ND	ND	ND	ND
CHATTANOOGA, TN-GA	426,000	45	ND	ND	ND	ND	0.12	ND
CHEYENNE, WY	75,000	30	ND	ND	ND	ND	ND	ND
CHICAGO, IL	6,188,000	45	0.011	0.053	9	0.043	0.16	0.18
CHICO, CA	167,000	48	ND	ND	8	0.017	0.10	0.03
CINCINNATI, OH-KY-IN	1,419,000	43	0.018	0.076	6	0.033	0.15	0.11

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION
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PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

(1) IMPACT FROM INDUSTRIAL PB SOURCE IN LEEDS, AL. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN BIRMINGHAM, AL IS 0.21 UG/M3.

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

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CLARKSVILLE-HOPKINSVILLE, TN-KY	154,000	ND	0.005	0.040	ND	ND	ND	ND
CLEVELAND, OH	1,850,000	51	0.016	0.076	7	0.031	0.13	0.43
COLORADO SPRINGS, CO	380,000	28	ND	ND	9	ND	0.10	0.00
COLUMBIA, MO	106,000	IN	ND	ND	ND	ND	ND	ND
COLUMBIA, SC	445,000	36	IN	0.011	7	ND	0.12	0.08
COLUMBUS, GA-AL	251,000	ND	ND	ND	ND	ND	0.12	ND
COLUMBUS, OH	1,299,000	40	0.009	0.032	6	ND	0.12	0.10
CORPUS CHRISTI, TX	363,000	33	0.003	0.018	ND	ND	0.14	0.09
CUMBERLAND, MD-WV	102,000	ND	0.012	0.047	5	ND	0.09	ND
DALLAS, TX	2,401,000	29	0.004	0.017	5	0.023	0.15	1.27 (1)
DANBURY, CT	186,000	ND	0.008	0.035	ND	ND	0.15	0.10
DANVILLE, VA	110,000	ND	ND	ND	ND	ND	ND	ND
DAVENPORT-ROCK ISLAND-MOLINE, IA-IL	371,000	30	0.004	0.018	5	ND	0.10	0.03
DAYTON-SPRINGFIELD, OH	934,000	48	0.007	0.031	6	ND	0.12	0.09
DAYTONA BEACH, FL	321,000	ND	0.002	0.009	ND	ND	ND	ND
DECATUR, IL	127,000	40	0.013	0.081	ND	ND	0.10	0.09
DENVER, CO	1,633,000	46	0.009	0.025	16	0.041	0.12	0.15
DES MOINES, IA	381,000	40	ND	ND	6	ND	0.05	0.02
DETROIT, MI	4,335,000	42	0.015	0.062	9	0.023	0.13	0.14
DOTHAN, AL	130,000	ND	ND	ND	ND	ND	ND	ND
DUBUQUE, IA	91,000	ND	0.005	0.026	7	ND	ND	ND
DULUTH, MN-WI	244,000	28	0.004	0.013	9	ND	ND	0.09
EAU CLAIRE, WI	137,000	ND	ND	ND	ND	ND	ND	ND
EL PASO, TX	561,000	54	0.018	0.070	15	0.023	0.17	1.38 (2)
ELKHART-GOSHEN, IN	146,000	ND	ND	ND	ND	ND	ND	ND
ELMIRA, NY	91,000	ND	0.005	0.029	ND	ND	0.10	ND
ENID, OK	63,000	ND	ND	ND	ND	ND	ND	ND
ERIE, PA	279,000	31	0.013	0.045	5	0.016	0.11	ND
EUGENE-SPRINGFIELD, OR	263,000	43	ND	ND	7	ND	0.11	0.08
EVANSVILLE, IN-KY	281,000	ND	0.017	0.079	3	0.021	0.12	ND
FALL RIVER, MA-RI	158,000	ND	0.010	0.053	ND	ND	ND	ND
FARGO-MOORHEAD, ND-MN	145,000	20	ND	ND	ND	ND	ND	ND
FAYETTEVILLE, NC	259,000	32	ND	ND	ND	ND	ND	ND
FAYETTEVILLE-SPRINGDALE, AR	107,000	ND	ND	ND	ND	ND	ND	ND
FITCHBURG-LEOMINSTER, MA	96,000	ND	ND	ND	ND	ND	ND	ND

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
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ND = INDICATES DATA NOT AVAILABLE
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(1) IMPACT FROM PB RECLAMATION PLANT IN FRISCO, TX. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN DALLAS, TX IS 0.47 UG/M3.

(2) IMPACT FROM PB SMELTER. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN EL PASO, TX 0.40 UG/M3.

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METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
FLINT, MI	435,000	IN	0.005	0.020	ND	ND	0.12	0.05
FLORENCE, AL	138,000	ND	0.007	0.071	ND	ND	ND	ND
FLORENCE, SC	116,000	ND	ND	ND	ND	ND	ND	ND
FORT COLLINS, CO	175,000	30	ND	ND	13	ND	0.08	ND
FORT LAUDERDALE-HOLLYWOOD-POMPANO BE	1,142,000	28	ND	ND	6	ND	0.10	0.04
FORT MYERS-CAPE CORAL, FL	279,000	ND	ND	ND	ND	ND	ND	ND
FORT PIERCE, FL	206,000	ND	ND	ND	ND	ND	ND	ND
FORT SMITH, AR-OK	176,000	ND	ND	ND	ND	ND	ND	ND
FORT WALTON BEACH, FL	141,000	ND	ND	ND	ND	ND	ND	ND
FORT WAYNE, IN	356,000	38	0.005	0.018	ND	0.009	0.11	ND
FORT WORTH-ARLINGTON, TX	1,254,000	28	0.002	0.010	6	0.015	0.14	0.12
FRESNO, CA	588,000	63	0.002	0.010	11	0.030	0.17	0.10
GADSDEN, AL	102,000	44	ND	ND	ND	ND	ND	ND
GAINESVILLE, FL	200,000	ND	0.002	0.009	ND	ND	ND	ND
GALVESTON-TEXAS CITY, TX	215,000	27	0.006	0.053	ND	ND	0.13	0.08
GARY-HAMMOND, IN	615,000	64	0.012	0.051	5	ND	0.16	2.56 (1)
GLENS FALLS, NY	112,000	ND	0.006	0.029	ND	ND	ND	ND
GRAND FORKS, ND	69,000	24	ND	ND	ND	ND	ND	ND
GRAND RAPIDS, MI	649,000	IN	0.006	0.054	5	ND	0.14	0.19
GREAT FALLS, MT	79,000	26	ND	ND	11	ND	ND	ND
GREELEY, CO	135,000	31	ND	ND	11	ND	0.09	ND
GREEN BAY, WI	187,000	40	0.007	0.050	ND	ND	0.11	ND
GREENSBORO-WINSTON SALEM-HIGH POINT,	899,000	40	0.008	0.028	7	0.018	0.11	ND
GREENVILLE-SPARTANBURG, SC	606,000	36	ND	ND	ND	ND	0.11	0.11
HAGERSTOWN, MD	114,000	ND	ND	ND	ND	ND	ND	ND
HAMILTON-MIDDLETOWN, OH	271,000	45	IN	0.029	ND	ND	0.10	ND
HARRISBURG-LEBANON-CARLISLE, PA	577,000	29	0.009	0.031	7	0.022	0.13	ND
HARTFORD, CT	739,000	35	0.010	0.054	11	0.020	0.14	0.11
HICKORY, NC	218,000	ND	0.003	0.016	ND	ND	0.10	ND
HONOLULU, HI	817,000	22	0.001	0.005	4	ND	0.04	0.00
HOUMA-THIBODAUX, LA	189,000	ND	ND	ND	ND	ND	ND	ND
HOUSTON, TX	3,231,000	41	0.009	0.031	9	0.030	0.18	0.12
HUNTINGTON-ASHLAND, WV-KY-OH	328,000	49	0.015	0.067	5	0.016	0.14	0.11
HUNTSVILLE, AL	234,000	ND	ND	ND	ND	ND	0.11	ND
INDIANAPOLIS, IN	1,213,000	47	0.016	0.067	7	0.023	0.12	1.15 (2)

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
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(1) IMPACT FROM PB BATTERY PLANT IN HAMMOND, IN. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN GARY, IN IS 0.20 UG/M3.

(2) IMPACT FROM PB BATTERY PLANT. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN INDIANAPOLIS, IN IS 0.13 UG/M3.

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IOWA CITY, IA	85,000	ND	ND	ND	ND	ND	0.09	ND
JACKSON, MI	144,000	ND	ND	ND	ND	ND	ND	ND
JACKSON, MS	392,000	32	ND	ND	4	ND	0.09	0.12
JACKSON, TN	78,000	36	ND	ND	ND	ND	ND	ND
JACKSONVILLE, FL	853,000	34	0.008	0.087	7	0.018	0.12	0.13
JACKSONVILLE, NC	127,000	ND	ND	ND	ND	ND	ND	ND
JANESVILLE-BELOIT, WI	138,000	34	0.004	0.023	ND	0.012	0.10	ND
JERSEY CITY, NJ	553,000	37	0.014	0.041	8	0.031	0.16	0.10
JOHNSON CITY-KINGSPORT-BRISTOL, TN-V	443,000	40	0.012	0.064	5	0.020	0.10	0.00
JOHNSTOWN, PA	254,000	ND	0.016	0.065	6	0.020	0.12	0.52
JOLIET, IL	370,000	34	ND	ND	ND	ND	0.11	0.03
JOPLIN, MO	133,000	ND	ND	ND	ND	ND	ND	ND
KALAMAZOO, MI	218,000	ND	ND	ND	ND	ND	ND	0.06
KANKAKEE, IL	98,000	ND	ND	ND	ND	ND	ND	ND
KANSAS CITY, MO-KS	1,518,000	75	0.011	0.047	8	0.019	0.12	0.08
KENOSHA, WI	120,000	ND	0.007	0.037	ND	0.022	0.18	ND
KILLEN-TEMPLE, TX	234,000	ND	ND	ND	ND	ND	ND	ND
KNOXVILLE, TN	591,000	42	0.012	0.041	ND	ND	0.12	ND
KOKOMO, IN	101,000	ND	ND	ND	ND	ND	ND	ND
LA CROSSE, WI	94,000	ND	ND	ND	ND	ND	0.09	ND
LAFAYETTE, LA	218,000	ND	ND	ND	ND	ND	0.11	ND
LAFAYETTE-WEST LAFAYETTE, IN	124,000	40	0.006	0.028	2	0.009	ND	0.03
LAKE CHARLES, LA	173,000	ND	0.002	0.007	ND	ND	0.13	ND
LAKE COUNTY, IL	480,000	ND	ND	ND	ND	ND	0.16	ND
LAKELAND-WINTER HAVEN, FL	377,000	ND	0.004	0.019	ND	ND	ND	ND
LANCASTER, PA	394,000	ND	0.007	0.027	3	0.019	0.12	0.09
LANSING-EAST LANSING, MI	425,000	24	0.006	0.023	ND	ND	0.11	0.04
LAREDO, TX	121,000	ND	ND	ND	ND	ND	ND	0.04
LAS CRUCES, NM	123,000	37	0.017	0.071	8	ND	0.12	0.44
LAS VEGAS, NV	569,000	43	ND	ND	12	0.028	0.11	ND
LAWRENCE, KS	73,000	ND	ND	ND	ND	ND	ND	ND
LAWRENCE-HAVERHILL, MA-NH	368,000	IN	0.010	0.045	ND	ND	0.13	ND
LAWTON, OK	121,000	ND	0.006	0.023	ND	ND	ND	ND
LEWISTON-AUBURN, ME	85,000	ND	0.009	0.034	ND	ND	ND	0.08
LEXINGTON-FAYETTE, KY	332,000	ND	0.007	0.031	6	0.017	0.11	ND

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
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LIMA, OH	154,000	ND	0.006	0.029	ND	ND	0.10	ND
LINCOLN, NE	206,000	ND	ND	ND	8	ND	0.06	ND
LITTLE ROCK-NORTH LITTLE ROCK, AR	506,000	31	0.002	0.006	ND	0.009	0.12	0.21
LONGVIEW-MARSHALL, TX	170,000	ND	ND	ND	ND	IN	0.12	ND
LORAIN-ELYRIA, OH	271,000	38	0.011	0.041	ND	ND	0.09	ND
LOS ANGELES-LONG BEACH, CA	8,296,000	68	0.006	0.021	17	0.055	0.32	0.27
LOUISVILLE, KY-IN	963,000	48	0.011	0.067	7	0.032	0.13	0.10
LOWELL, MA-NH	254,000	ND	ND	ND	ND	ND	ND	0.09
LUBBOCK, TX	225,000	34	ND	ND	ND	ND	ND	0.08
LYNCHBURG, VA	144,000	ND	ND	ND	ND	ND	ND	ND
MACON-WARNER ROBINS, GA	282,000	ND	ND	ND	ND	ND	ND	ND
MADISON, WI	345,000	ND	0.004	0.016	5	ND	0.10	ND
MANCHESTER, NH	145,000	IN	0.009	0.040	10	0.020	0.10	0.06
MANSFIELD, OH	129,000	ND	0.009	0.035	ND	ND	ND	ND
MAYAGUEZ, PR	210,000	ND	ND	ND	ND	ND	ND	ND
MCALLEN-EDINBURG-MISSION, TX	366,000	ND	ND	ND	ND	ND	ND	0.03
MEDFORD, OR	140,000	82	ND	ND	10	ND	0.09	0.07
MELBOURNE-TITUSVILLE-PALM BAY, FL	361,000	ND	ND	ND	ND	ND	ND	ND
MEMPHIS, TN-AR-MS	959,000	35	0.014	0.067	11	IN	0.13	0.33
MERCED, CA	164,000	44	ND	ND	ND	ND	ND	ND
MIAMI-HIALEAH, FL	1,770,000	38	0.002	0.008	8	0.012	0.15	0.15
MIDDLESEX-SOMERSET-HUNTERDON, NJ	950,000	ND	0.011	0.035	5	0.027	0.19	0.17
MIDDLETOWN, CT	84,000	ND	ND	ND	ND	ND	0.17	0.07
MIDLAND, TX	111,000	ND	ND	ND	ND	ND	ND	ND
MILWAUKEE, WI	1,380,000	40	0.006	0.027	5	0.027	0.18	0.16
MINNEAPOLIS-ST. PAUL, MN-WI	2,295,000	41	0.017	0.090	13	0.020	0.11	1.51 (1)
MOBILE, AL	470,000	48	0.009	0.052	ND	ND	0.11	ND
MODESTO, CA	317,000	44	0.003	0.010	9	0.024	0.15	ND
MONMOUTH-OCEAN, NJ	935,000	ND	ND	ND	6	ND	ND	ND
MONROE, LA	146,000	ND	0.006	0.025	ND	ND	0.10	ND
MONTGOMERY, AL	299,000	28	ND	ND	ND	ND	0.14	ND
MUNCIE, IN	121,000	ND	ND	ND	ND	ND	ND	ND
MUSKEGON, MI	159,000	ND	0.005	0.021	4	ND	0.18	0.04
NAPLES, FL	121,000	ND	ND	ND	ND	ND	ND	ND
NASHUA, NH	163,000	ND	0.008	0.034	9	ND	0.10	0.05

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PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

(1) IMPACT FROM PB POINT SOURCE IN EAGAN, MN. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN MINNEAPOLIS, MN IS 0.08 UG/M3.

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
NASHVILLE, TN	931,000	47	0.012	0.043	9	ND	0.14	1.50 (1)
NASSAU-SUFFOLK, NY	2,635,000	ND	0.011	0.049	10	0.032	0.17	0.07
NEW BEDFORD, MA	170,000	ND	ND	ND	ND	ND	0.12	ND
NEW BRITAIN, CT	144,000	ND	0.010	0.045	ND	ND	ND	0.06
NEW HAVEN-MERIDEN, CT	512,000	58	0.015	0.068	8	0.028	0.16	0.22
NEW LONDON-NORWICH, CT-RI	260,000	ND	0.007	0.029	ND	ND	0.16	0.06
NEW ORLEANS, LA	1,334,000	37	0.003	0.012	7	0.026	0.12	0.10
NEW YORK, NY	8,473,000	42	0.020	0.076	20	0.043	0.18	0.14
NEWARK, NJ	1,889,000	39	0.013	0.053	9	0.042	0.18	0.58
NIAGARA FALLS, NY	217,000	ND	0.012	0.052	5	ND	0.13	ND
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS,	1,309,000	38	0.007	0.027	9	0.019	0.13	0.10
NORWALK, CT	128,000	ND	0.009	0.049	ND	ND	ND	0.06
OAKLAND, CA	1,934,000	30	0.002	0.013	5	0.025	0.15	0.33
OCALA, FL	171,000	ND	ND	ND	ND	ND	ND	ND
ODESSA, TX	133,000	22	ND	ND	ND	ND	ND	0.00
OKLAHOMA CITY, OK	983,000	31	0.005	0.012	11	0.019	0.11	0.09
OLYMPIA, WA	147,000	ND	ND	ND	ND	ND	ND	ND
OMAHA, NE-IA	614,000	38	IN	0.006	8	ND	0.09	1.20 (2)
ORANGE COUNTY, NY	282,000	ND	ND	ND	ND	ND	ND	1.68 (3)
ORLANDO, FL	898,000	ND	0.002	0.008	6	ND	0.11	ND
OWENSBORO, KY	88,000	ND	0.008	0.033	4	0.015	0.11	0.11
OXNARD-VENTURA, CA	611,000	35	0.001	0.010	5	0.022	0.17	0.05
PANAMA CITY, FL	122,000	ND	ND	ND	ND	ND	ND	ND
PARKERBURG-MARIETTA, WV-OH	156,000	ND	0.017	0.070	ND	ND	0.15	0.08
PASCAGOULA, MS	128,000	ND	0.006	0.012	ND	ND	0.11	ND
PAWTUCKET-WOONSOCKET-ATTLEBORO, RI-M	317,000	30	0.012	0.050	ND	ND	ND	ND
PENSACOLA, FL	337,000	ND	0.010	0.086	ND	ND	0.12	ND
PEORIA, IL	340,000	ND	0.009	0.062	7	ND	0.12	0.04
PHILADELPHIA, PA-NJ	4,826,000	42	0.015	0.074	9	0.043	0.18	1.52 (4)
PHOENIX, AZ	1,900,000	ND	0.001	0.010	13	ND	0.12	0.27
PINE BLUFF, AR	90,000	ND	ND	ND	ND	ND	ND	ND
PITTSBURGH, PA	2,123,000	45	0.025	0.155	9	0.032	0.19	0.10
PITTSFIELD, MA	81,000	ND	ND	ND	ND	ND	ND	ND
PONCE, PR	235,000	ND	ND	ND	ND	ND	ND	ND
PORTLAND, ME	206,000	31	0.012	0.042	6	ND	0.14	0.06

TSP = HIGHEST GEOMETRIC MEAN CONCENTRATION
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HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION
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PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION

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UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

(1) IMPACT FROM PB POINT SOURCE IN WILLIAMSON COUNTY. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN NASHVILLE, TN IS 0.18 UG/M3.

(2) IMPACT FROM PB POINT SOURCE IN OMAHA, NE. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN OMAHA, NE IS 0.40 UG/M3.

(3) IMPACT FROM PB POINT SOURCE IN ORANGE COUNTY, NY. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN NEW YORK, NY IS 0.18 UG/M3.

(4) IMPACT FROM PB BATTERY RECLAMATION PLANT. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN PHILADELPHIA, PA IS 0.14 UG/M3.

TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
PORTLAND, OR-WA	1,153,000	48	0.006	0.018	9	0.019	0.11	0.28
PORTSMOUTH-DOVER-ROCHESTER, NH-ME	215,000	ND	0.005	0.025	ND	ND	0.13	0.06
POUGHKEEPSIE, NY	257,000	ND	0.009	0.050	ND	ND	0.10	ND
PROVIDENCE, RI	634,000	31	0.016	0.052	8	0.025	0.16	0.14
PROVO-OREM, UT	241,000	39	ND	ND	13	0.024	0.10	0.13
PUEBLO, CO	127,000	ND	ND	ND	ND	ND	ND	0.05
RACINE, WI	172,000	29	0.005	0.021	7	ND	0.18	ND
RALEIGH-DURHAM, NC	651,000	37	ND	ND	10	ND	0.13	ND
RAPID CITY, SD	77,000	35	ND	ND	ND	ND	ND	ND
READING, PA	321,000	ND	0.014	0.047	5	0.025	0.12	0.43
REDDING, CA	133,000	32	ND	ND	2	0.016	0.13	ND
RENO, NV	225,000	61	ND	ND	9	IN	0.08	ND
RICHLAND-KENNEWICK-PASCO, WA	150,000	27	ND	ND	ND	ND	ND	ND
RICHMOND-PETERSBURG, VA	810,000	31	0.007	0.031	8	0.026	0.14	ND
RIVERSIDE-SAN BERNARDINO, CA	2,001,000	90	0.003	0.008	7	0.047	0.27	ND
ROANOKE, VA	225,000	37	0.004	0.023	2	0.016	0.11	ND
ROCHESTER, MN	98,000	28	0.003	0.032	9	ND	ND	ND
ROCHESTER, NY	980,000	24	0.013	0.052	4	ND	0.12	0.12
ROCKFORD, IL	280,000	ND	ND	ND	8	ND	0.09	0.05
SACRAMENTO, CA	1,291,000	39	ND	ND	13	0.022	0.16	0.09
SAGINAW-BAY CITY-MIDLAND, MI	404,000	42	0.007	0.068	3	ND	ND	0.06
ST. CLOUD, MN	175,000	30	IN	0.005	7	ND	ND	ND
ST. JOSEPH, MO	86,000	41	ND	ND	ND	ND	ND	ND
ST. LOUIS, MO-IL	2,438,000	70	0.020	0.092	11	0.029	0.17	3.46 (1)
SALEM, OR	262,000	ND	ND	ND	8	ND	ND	0.08
SALEM-GLOUCESTER, MA	259,000	ND	ND	ND	ND	ND	ND	ND
SALINAS-SEASIDE-MONTEREY, CA	340,000	25	0.001	0.003	2	0.013	0.09	0.05
SALT LAKE CITY-OGDEN, UT	1,041,000	53	0.012	0.102	10	0.032	0.11	0.18
SAN ANGELO, TX	98,000	ND	ND	ND	ND	ND	ND	ND
SAN ANTONIO, TX	1,276,000	35	0.001	0.005	7	ND	0.12	0.15
SAN DIEGO, CA	2,201,000	38	0.005	0.018	8	0.032	0.18	0.16
SAN FRANCISCO, CA	1,588,000	30	0.002	0.010	9	0.024	0.10	0.16
SAN JOSE, CA	1,402,000	44	ND	ND	7	0.031	0.15	0.26
SAN JUAN, PR	1,541,000	39	IN	0.029	5	ND	0.09	0.24
SANTA BARBARA-SANTA MARIA-LOMPOC, CA	339,000	30	0.003	0.012	7	0.025	0.13	0.08

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(1) IMPACT FROM PB POINT SOURCE IN HERCULANEUM, MO. THE 1987 PB LEVEL AT THE HIGHEST POPULATION ORIENTED SITE IN ST. LOUIS, MO IS 0.21 UG/M3.

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TABLE 4-3. 1987 METROPOLITAN STATISTICAL AREA AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
SANTA CRUZ, CA	218,000	30	ND	ND	ND	ND	0.09	ND
SANTA FE, NM	106,000	ND	ND	ND	4	ND	ND	ND
SANTA ROSA-PETALUMA, CA	344,000	27	ND	ND	4	0.016	0.10	0.05
SARASOTA, FL	248,000	ND	0.002	0.008	ND	ND	0.08	ND
SAVANNAH, GA	240,000	38	0.002	0.010	ND	ND	ND	ND
SCRANTON-WILKES-BARRE, PA	726,000	29	0.011	0.050	6	0.020	0.12	ND
SEATTLE, WA	1,751,000	46	0.013	0.034	10	IN	0.09	0.43
SHARON, PA	124,000	35	0.009	0.037	ND	ND	0.12	ND
SHEBOYGAN, WI	103,000	ND	0.004	0.023	ND	ND	0.20	ND
SHERMAN-DENISON, TX	98,000	ND	ND	ND	ND	ND	ND	ND
SHREVEPORT, LA	365,000	31	0.003	0.010	ND	ND	0.11	ND
SIOUX CITY, IA-NE	116,000	IN	ND	ND	ND	ND	ND	ND
SIOUX FALLS, SD	123,000	23	ND	ND	ND	ND	ND	ND
SOUTH BEND-MISHAWAKA, IN	241,000	32	0.008	0.030	4	ND	0.12	ND
SPOKANE, WA	357,000	59	ND	ND	19	ND	ND	ND
SPRINGFIELD, IL	191,000	ND	0.008	0.039	5	ND	0.10	ND
SPRINGFIELD, MO	518,000	27	0.010	0.131	8	0.003	0.09	ND
SPRINGFIELD, MA	225,000	32	0.012	0.053	9	0.022	0.12	0.16
STAMFORD, CT	195,000	ND	0.011	0.042	6	ND	0.17	0.10
STATE COLLEGE, PA	115,000	ND	ND	ND	ND	ND	ND	ND
STEUBENVILLE-WEIRTON, OH-WV	153,000	69	0.033	0.157	19	0.020	0.10	0.17
STOCKTON, CA	433,000	49	0.004	0.016	6	0.025	0.12	0.07
SYRACUSE, NY	649,000	49	0.005	0.020	10	ND	0.11	0.07
TACOMA, WA	533,000	48	0.008	0.035	15	ND	0.10	0.09
TALLAHASSEE, FL	218,000	ND	ND	ND	ND	ND	0.08	ND
TAMPA-ST. PETERSBURG-CLEARWATER, FL	1,914,000	35	0.010	0.046	6	0.024	0.16	ND
TERRE HAUTE, IN	134,000	42	0.010	0.035	ND	IN	0.11	ND
TEXARKANA, TX-AR	120,000	ND	ND	ND	ND	ND	ND	ND
TOLEDO, OH	611,000	30	0.009	0.044	5	ND	0.12	0.65
TOPEKA, KS	161,000	ND	ND	ND	ND	ND	ND	0.05
TRENTON, NJ	321,000	31	0.008	0.041	6	ND	0.16	ND
TUCSON, AZ	602,000	38	0.003	0.013	7	0.019	0.09	0.10
TULSA, OK	734,000	33	0.010	0.085	7	0.015	0.12	0.33
TUSCALOOSA, AL	141,000	ND	ND	ND	ND	ND	ND	ND
TYLER, TX	152,000	ND	ND	ND	ND	ND	ND	0.05

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METROPOLITAN STATISTICAL AREA	1986 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
UTICA-ROME, NY	315,000	ND	ND	ND	ND	ND	0.11	ND
VALLEJO-FAIRFIELD-NAPA, CA	392,000	33	0.002	0.011	8	0.018	0.12	0.13
VANCOUVER, WA	211,000	ND	ND	ND	12	ND	ND	ND
VICTORIA, TX	76,000	ND	ND	ND	ND	ND	ND	ND
VINELAND-MILLVILE-BRIDGETON, NJ	135,000	ND	0.007	0.038	ND	ND	0.14	ND
VISALIA-TULARE-PORTERVILLE, CA	287,000	61	0.003	0.020	6	0.019	0.15	0.03
WACO, TX	188,000	ND	ND	ND	ND	ND	ND	0.03
WASHINGTON, DC-MD-VA	3,563,000	39	0.014	0.051	11	0.031	0.16	0.10
WATERBURY, CT	212,000	33	0.012	0.059	ND	ND	ND	0.14
WATERLOO-CEDAR FALLS, IA	152,000	ND	ND	ND	ND	ND	ND	ND
WAUSAU, WI	112,000	ND	0.008	0.067	ND	ND	0.09	ND
WEST PALM BEACH-BOCA RATON-DELRAY BE	756,000	ND	0.001	0.005	4	0.012	0.09	ND
WHEELING, WV-OH	175,000	30	0.021	0.082	6	0.019	0.12	0.06
WICHITA, KS	470,000	27	ND	ND	9	ND	0.10	0.04
WICHITA FALLS, TX	127,000	ND	ND	ND	ND	ND	ND	0.03
WILLIAMSPORT, PA	116,000	ND	0.006	0.026	ND	ND	0.09	ND
WILMINGTON, DE-NJ-MD	551,000	34	0.016	0.052	5	0.032	0.15	0.10
WILMINGTON, NC	114,000	IN	ND	ND	ND	ND	ND	ND
WORCESTER, MA	408,000	29	0.009	0.039	7	0.034	0.11	0.06
YAKIMA, WA	183,000	78	ND	ND	11	ND	ND	ND
YORK, PA	398,000	28	0.008	0.032	5	0.025	0.12	ND
YOUNGSTOWN-WARREN, OH	510,000	31	0.010	0.043	4	ND	0.11	ND
YUBA CITY, CA	114,000	40	ND	ND	ND	ND	0.11	ND

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION
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CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION
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5. TRENDS ANALYSES FOR FOURTEEN METROPOLITAN STATISTICAL AREAS

This chapter presents trends and analyses in ambient air quality for the period 1983 through 1987 in 14 consolidated metropolitan statistical areas (CMSA) or metropolitan statistical areas (MSA). Consolidated metropolitan statistical areas are metropolitan complexes of one million or more population which have separate component areas designated primary metropolitan statistical areas. For example, the New York-Northern New Jersey-Long Island, NY-NJ-CT CMSA contains 12 MSAs which are listed separately in Section 4. There are 21 metropolitan complexes designated as CMSAs, 9 of which have been selected for trends analysis. The areas included in these analyses are Atlanta, GA MSA; Baltimore, MD MSA; Boston-Lawrence-Salem, MA-NH CMSA; Chicago-Gary-Lake County, IL-IN-WI CMSA; Denver, CO MSA; Detroit-Ann Arbor, MI CMSA; Houston-Galveston-Brazoria, TX CMSA; Los Angeles-Anaheim-Riverside, CA CMSA; New York-Northern New Jersey-Long Island, NY-NJ-CT CMSA; Philadelphia-Wilmington-Trenton, PA-DE-MD-NJ CMSA; Phoenix, AZ MSA; Portland-Vancouver, OR-WA CMSA; Seattle-Tacoma, WA CMSA; and St. Louis, MO-IL MSA. These areas have been selected because they are among the largest cities in each of the EPA Regions.

Where sufficient data were available, trends in these areas are presented for the NAAQS pollutants TSP, SO_2, CO, NO_2, O_3, and Pb. Also, the CMSA/MSA areas are grouped into five broad geographic areas: East, Midwest, South, Southwest, and Northwest, and composite averages calculated for each pollutant are presented and are compared to the national averages.

The air quality data used for the trend statistics in this chapter have been obtained from the EPA Aerometric Information Retrieval System (AIRS), with additional limited data taken from State annual reports. This section employs the same data completeness and historical continuity criteria as the 5-year trends analyses in Section 3. That is, only those monitoring sites meeting the historical continuity criterion of 4 out of 5 years of "complete" data for the years 1983 through 1987 were selected for the trends analyses. Each year with data had to satisfy an annual data completeness criterion, also. For carbon monoxide, nitrogen dioxide and sulfur dioxide continuous instruments, data containing at least 4380 hourly observations from each year were used. Bubbler data were not used in these analyses. In the case of ozone, the second daily maximum 1-hour concentration was selected only from those sites with at least 50 percent of the daily data for the ozone season. Total suspended particulate data met the completeness criterion if there were at least 30 samples for the year. Finally, in the case of the pollutant lead, both 24-hour and composite data were used in the trends analyses. For the 24-hour data, the annual maximum quarterly mean had to satisfy the criterion of at least six samples per quarter in at least 3 of the

4 calendar quarters. Composite data were judged valid if at least two monthly samples were available for at least 3 of the 4 possible quarters.

Because this chapter only includes sites with sufficient data for trends, it is possible that an area will be violating a NAAQS but the trend graph will show the area as not violating. The air quality trends for each of the pollutants show in most cases a "highest air quality statistic among trend sites." For example, the annual second maximum 8-hour average in parts per million is used for CO. In St. Louis, the second maximums for 1986 and 1987 are below the NAAQS (9 ppm). However, a site which was not included (because it did not meet the historical continuity criterion of 4 out of 5 years) reported data not meeting the NAAQS. In 1988, EPA proposed that the St. Louis area be designated nonattainment. It is possible that areas may be violating the NAAQS but the statistics on the graphs do not show a violation because sites not meeting the completeness criteria were not included.

The CMSA/MSA area air quality trends focus on the period 1983 through 1987, complementing the 5-year national trends analyses in Chapter 3. The national trends analyses also produce a 10-year trend (1978 to 1987). However, only the 5-year trend is presented in this chapter.

The air quality trends in this chapter are based on information from monitoring sites within the CMSA/MSA areas as defined in the Statistical Abstract of the United States prepared by the U. S. Bureau of Census.[1] Before this year, sites within the urbanized areas of the 14 major cities were used to compile the trends. Since a CMSA/MSA is larger than an urbanized area, additional monitors from outlying areas are included in the trends analyses. Because these additional monitors are located farther from the core urbanized area, the overall effect for most cities is a lowering of the average and the minimum concentrations. In one case, expanding the area added point source oriented monitoring sites which increased the average concentration. Accordingly, comparisons to past reports should be avoided or done with caution because of these changes in the types and number of sampling sites.

Figure 5-1 shows the plotting convention used in trends analyses. For 1983 through 1987, maximum and minimum values are shown as well as the composite average of the sites used. The maximum and minimum values are measured concentrations. The values for the average concentration may include interpolated values from sites having incomplete data for a given year. In some years, the average value includes interpolated values from one or more sites, however in all years at least one measured value is included in the average. When only one site is available, or when the average concentration (which includes one or more interpolated values) exceeds the measured maximum value or is less than the measured minimum value, a maximum or minimum value is not plotted. Table 5-1 shows the air quality statistics used in the trends analyses for the 14 cities.

The air quality data and trends presented in this chapter should not be used to make direct city-to-city comparisons, since the mix, configuration, and number of sites composing the area networks are different. Furthermore, other parameters, such as population density, transportation patterns, industrial composition, emission sources, and meteorological characteristics, also need to be taken into consideration.

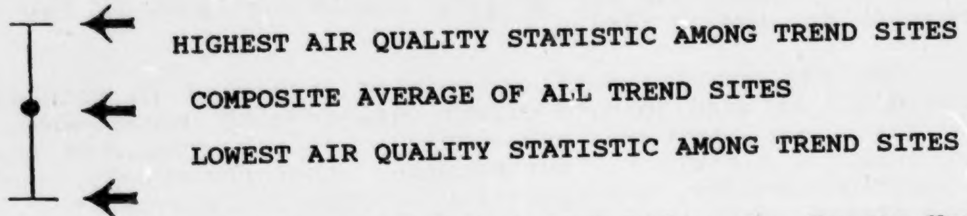
HIGHEST AIR QUALITY STATISTIC AMONG TREND SITES
COMPOSITE AVERAGE OF ALL TREND SITES
LOWEST AIR QUALITY STATISTIC AMONG TREND SITES

Figure 5-1. Illustration Of Plotting Conventions For Ranges Used In CMSA/MSA Area Trend Analysis.

TABLE 5-1. AIR QUALITY TREND STATISTICS AND THEIR ASSOCIATED NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)*

POLLUTANT	TREND STATISTICS	PRIMARY NAAQS CONCENTRATION
Total Suspended Particulate**	annual geometric mean	75 $\mu g/m^3$
Sulfur Dioxide	annual arithmetic mean	0.03 ppm (80 $\mu g/m^3$)
Carbon Monoxide	second highest nonoverlapping 8-hour average	9 ppm (10 $\mu g/m^3$)
Nitrogen Dioxide	annual arithmetic mean	0.053 ppm (100 $\mu g/m^3$)
Ozone	second highest daily maximum 1-hour average	0.12 ppm (235 $\mu g/m^3$)
Lead	maximum quarterly average	1.5 $\mu g/m^3$)

$\mu g/m^3$ = micrograms per cubic meter
ppm = parts per million

* See Table 2-1 for a more detailed description of NAAQS
** Replaced by PM_{10} on July 1, 1987 (see Chapter 3.1)

5.1 AIR QUALITY TRENDS FOR FIVE GEOGRAPHICAL AREAS

Figures 5-2 through 5-15 show the CMSA/MSA area trends 1983 through 1987 for the six NAAQS pollutants. Table 5-2 presents a pollutant-specific summary of the overall concentration changes in each of the 14 areas. These areas are grouped into five geographic areas: East, Midwest, South, Southwest, and Northwest.

East - Boston, New York, Baltimore, Philadelphia
Midwest - Chicago, Detroit, St. Louis
South - Atlanta, Houston
Southwest - Denver, Los Angeles, Phoenix
Northwest - Portland, Seattle

Composite geographic area averages of the 5-year change in air quality concentrations were calculated. In the individual geographic area averages, each city has equal weight, regardless of the number of monitors operating. For comparison to the national trends, however, each city's input is weighted by the number of monitors operating for a given pollutant. The following discussion addresses the findings.

Table 5.2 Percent Change in Air Quality Trend Statistics 1983 Through 1987

		TSP	Pb	SO_2	CO	NO_2	O_3
National		- 1	-70	- 9	-16	+ 2	- 8
East	Boston	+ 9	-74	+ 0	-38	+33	- 8
	New York	+ 1	-61[a]	-10	-25	- 3	-15
	Philadelphia	- 3	-62[b]	- 9	-13	- 3	- 9
	Baltimore	- 6	-81	-14	-33	+13	- 5
Midwest	Detroit	- 1	-73	-15	- 6	-	- 9
	Chicago	- 8	-70	-15	-37	+ 4	- 8
	St. Louis	+12	-33[c]	-21	+ 2	- 5	- 7
South	Atlanta	+10	-85	-19	-27	+14	- 2
	Houston	-21	-82	-21	- 5	0	-25
Southwest	Denver	-11	-76	-30	-21	- 9	-12
	Phoenix	+12	-75	-	-13	-	-16
	Los Angeles	+12	-59	-26	-17	- 3	-19
Northwest	Portland	+19	-67	-	-24	-	+ 3
	Seattle	+24	-31	-14	- 2	-	+13
Weighted Average[d]		0	-66	-16	-19	0	-12

[a] Source oriented sites decreased 4 percent, and traffic oriented sites decreased 81 percent.
[b] Source oriented site decreased 67 percent, and traffic oriented sites decreased 59 percent.
[c] Source oriented sites decreased 31 percent, and traffic oriented sites decreased 44 percent.
[d] Weighted by number of monitors in each city for comparison to national average.

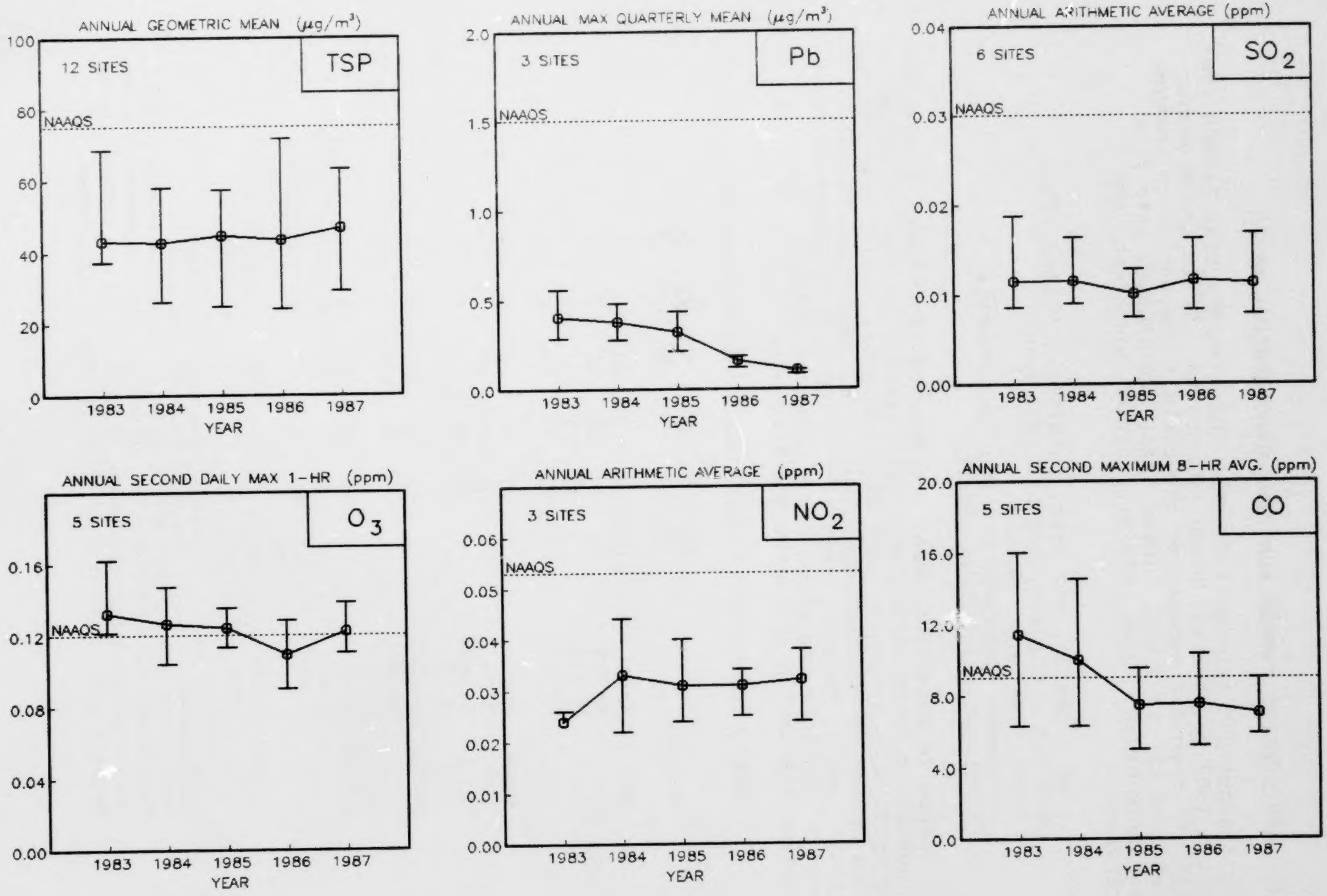

Figure 5-2. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Boston - Lawrence - Salem, MA-NH Consolidated Metropolitan Statistical Area, 1983-1987.

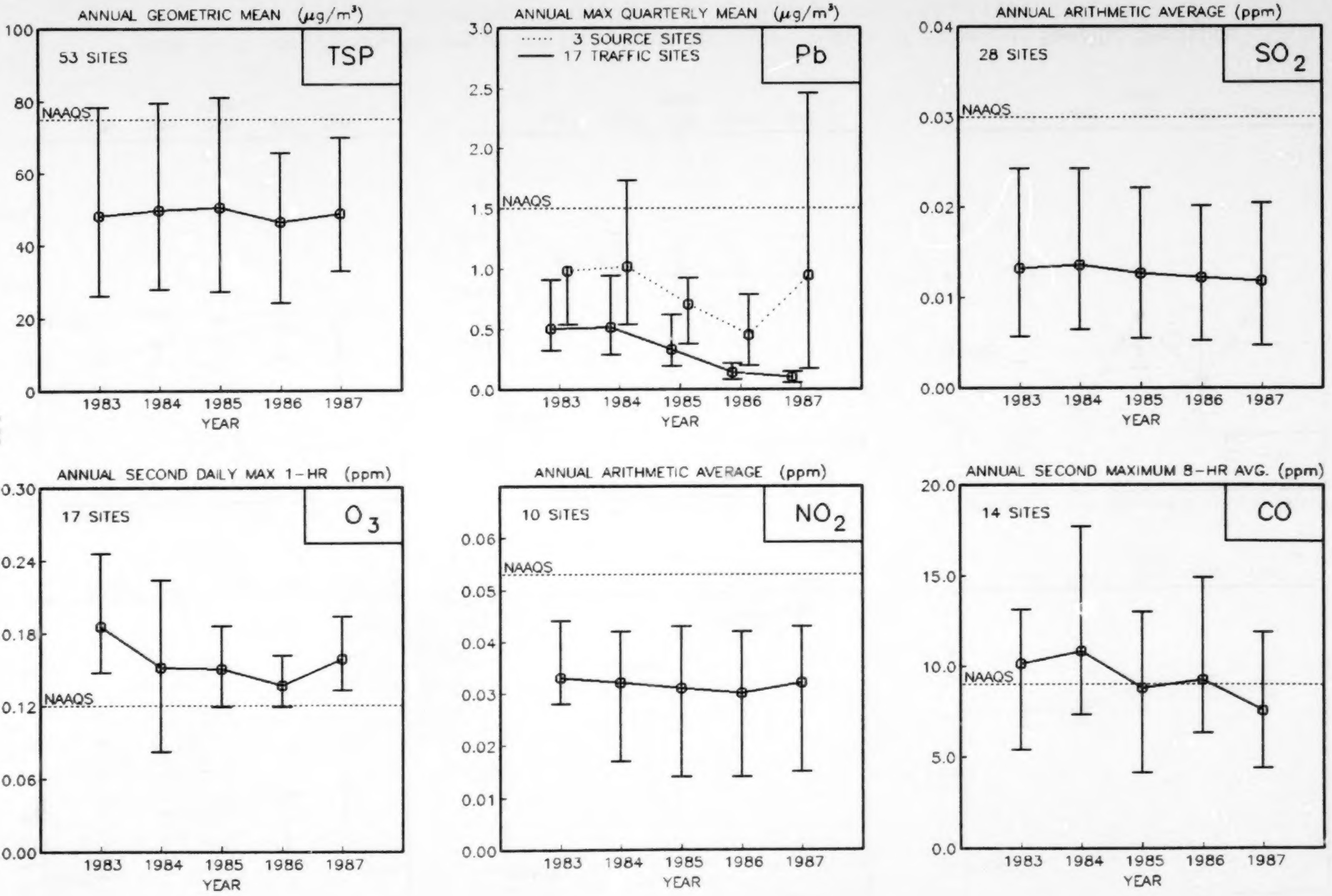

Figure 5–3. Air Quality Trends in the Composite Mean and Range of Pollutant–Specific Statistics for the New York – Northern New Jersey – Long Island, NY–NJ–CT Consolidated Metropolitan Statistical Area, 1983–1987.

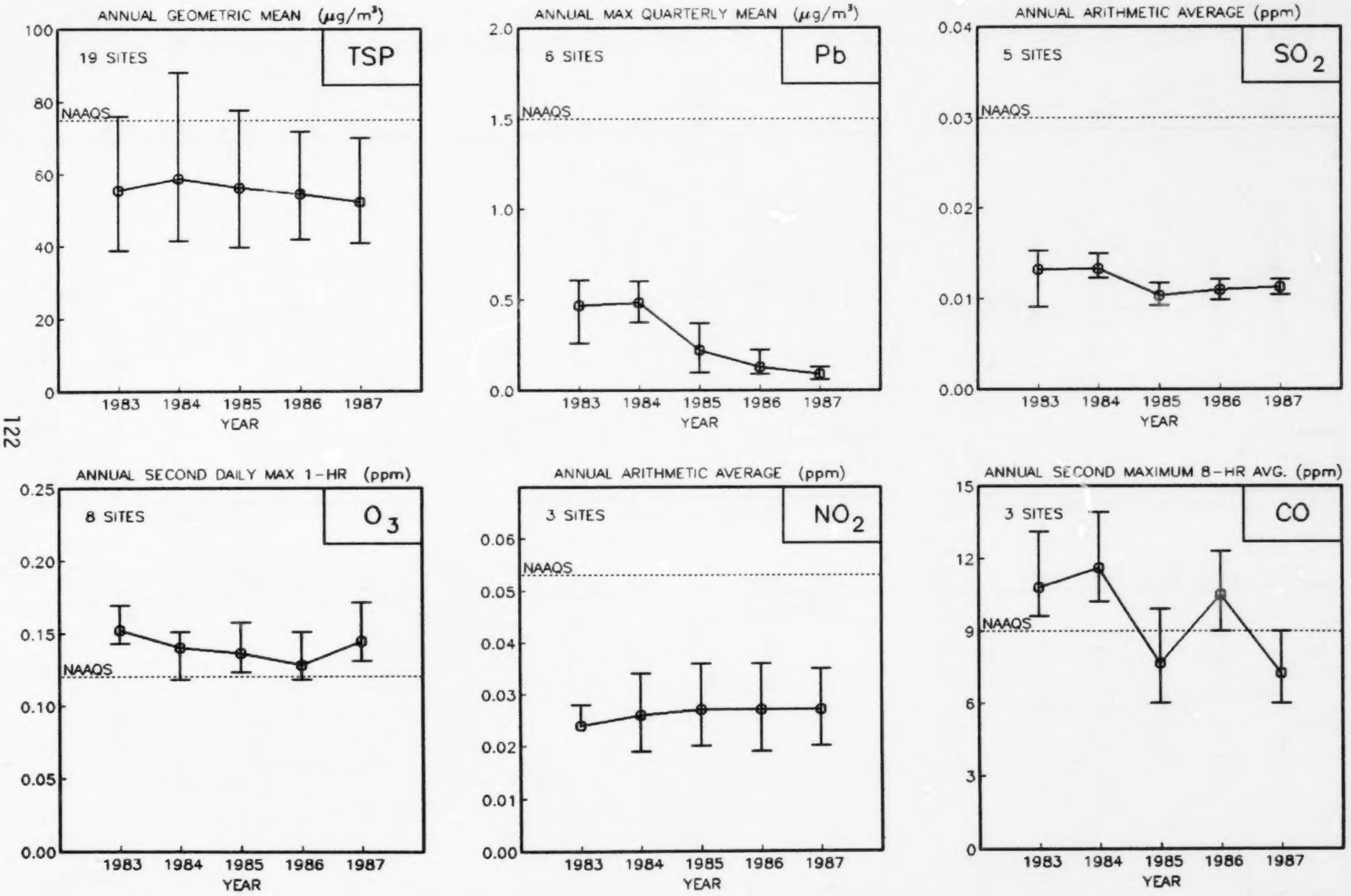

Figure 5-4. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Baltimore, MD Metropolitan Statistical Area, 1983-1987.

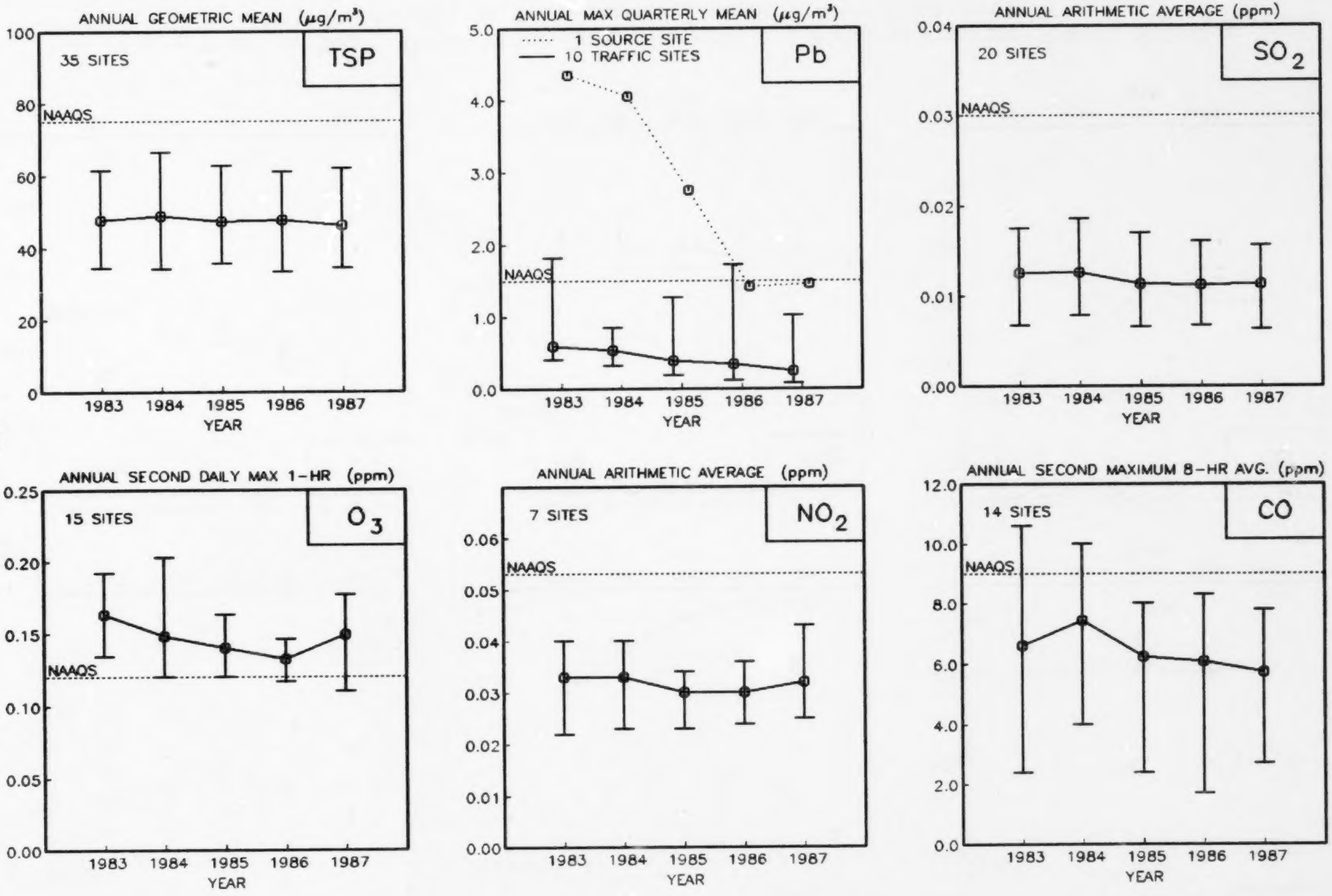

Figure 5-5. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Philadelphia - Wilmington - Trenton, PA-NJ-DE-MD Consolidated Metropolitan Statistical Area, 1983-1987.

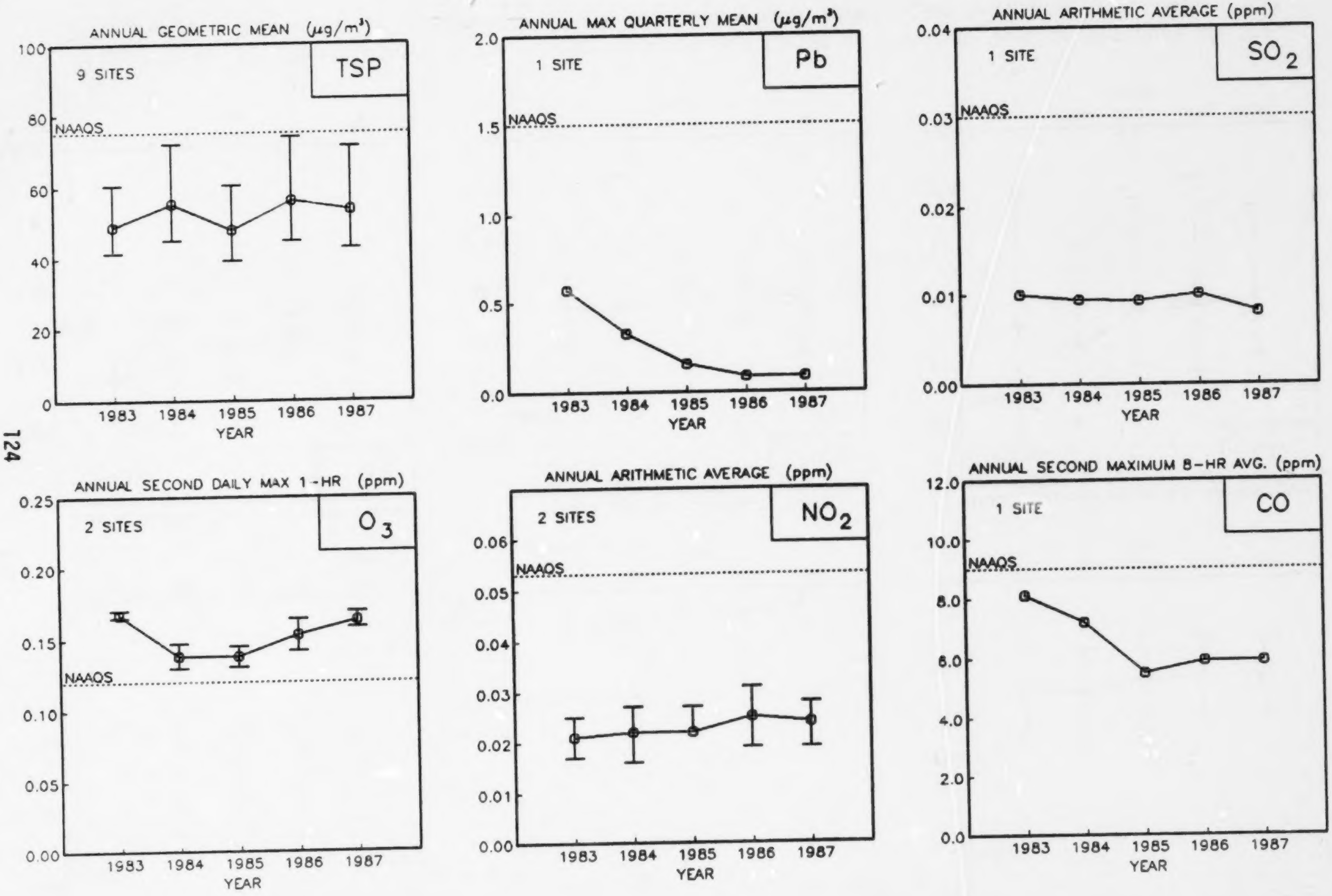

Figure 5–6. Air Quality Trends in the Composite Mean and Range of Pollutant–Specific Statistics for the Atlanta, GA Metropolitan Statistical Area, 1983–1987.

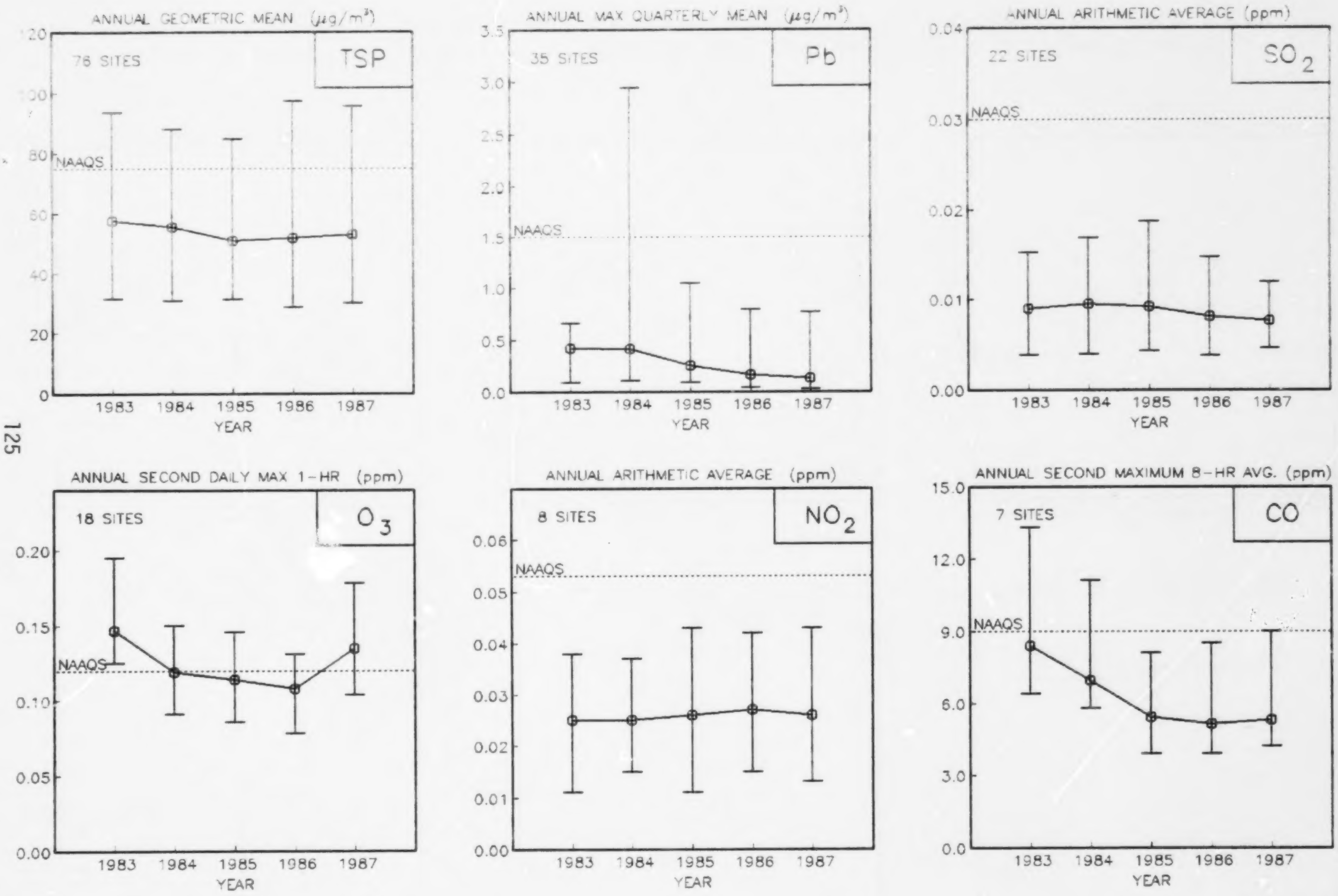

Figure 5-7. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Chicago - Gary - Lake County, IL-IN-WI Consolidated Metropolitan Statistical Area, 1983-1987.

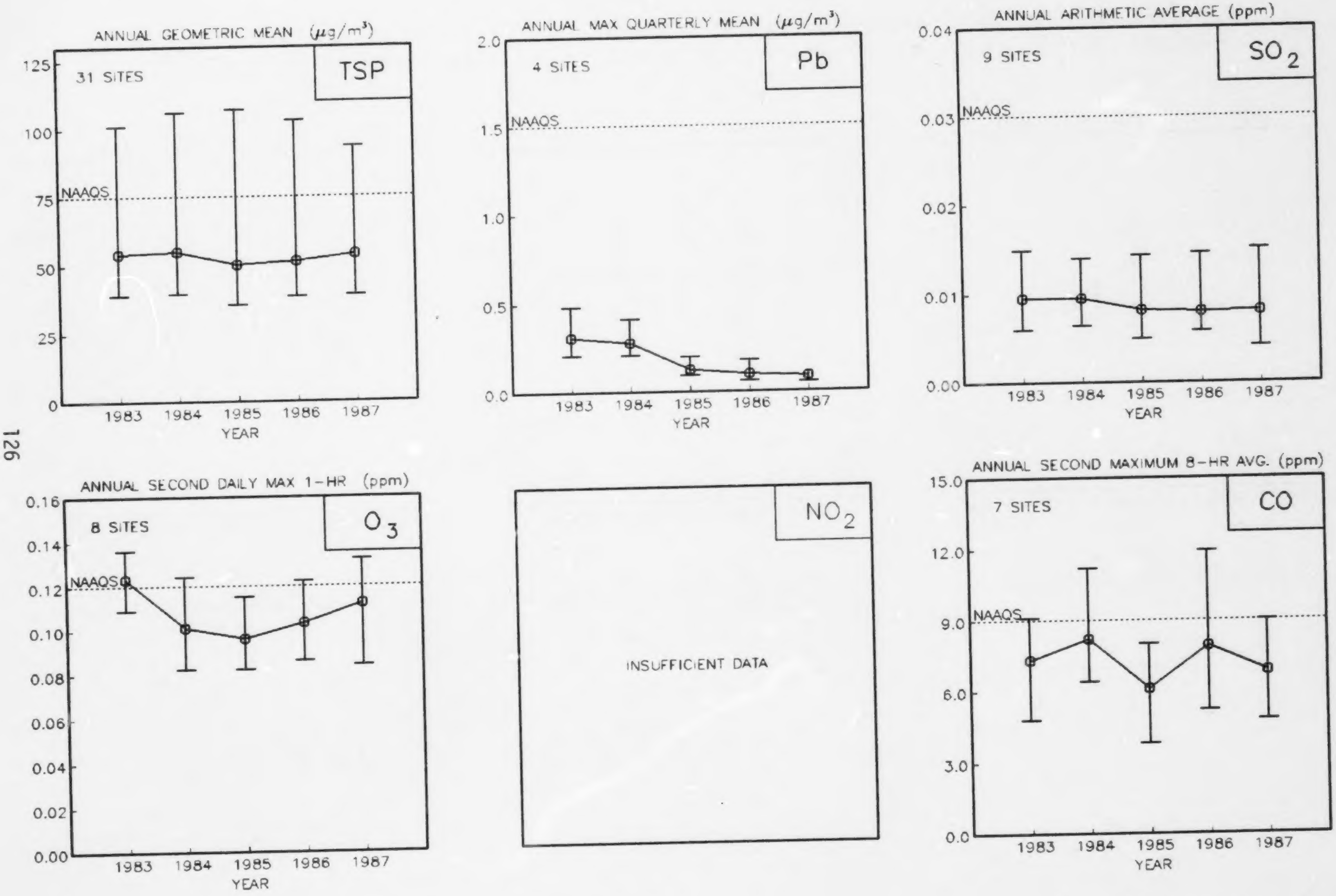

Figure 5-8. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Detroit - Ann Arbor, MI Consolidated Metropolitan Statistical Area, 1983-1987.

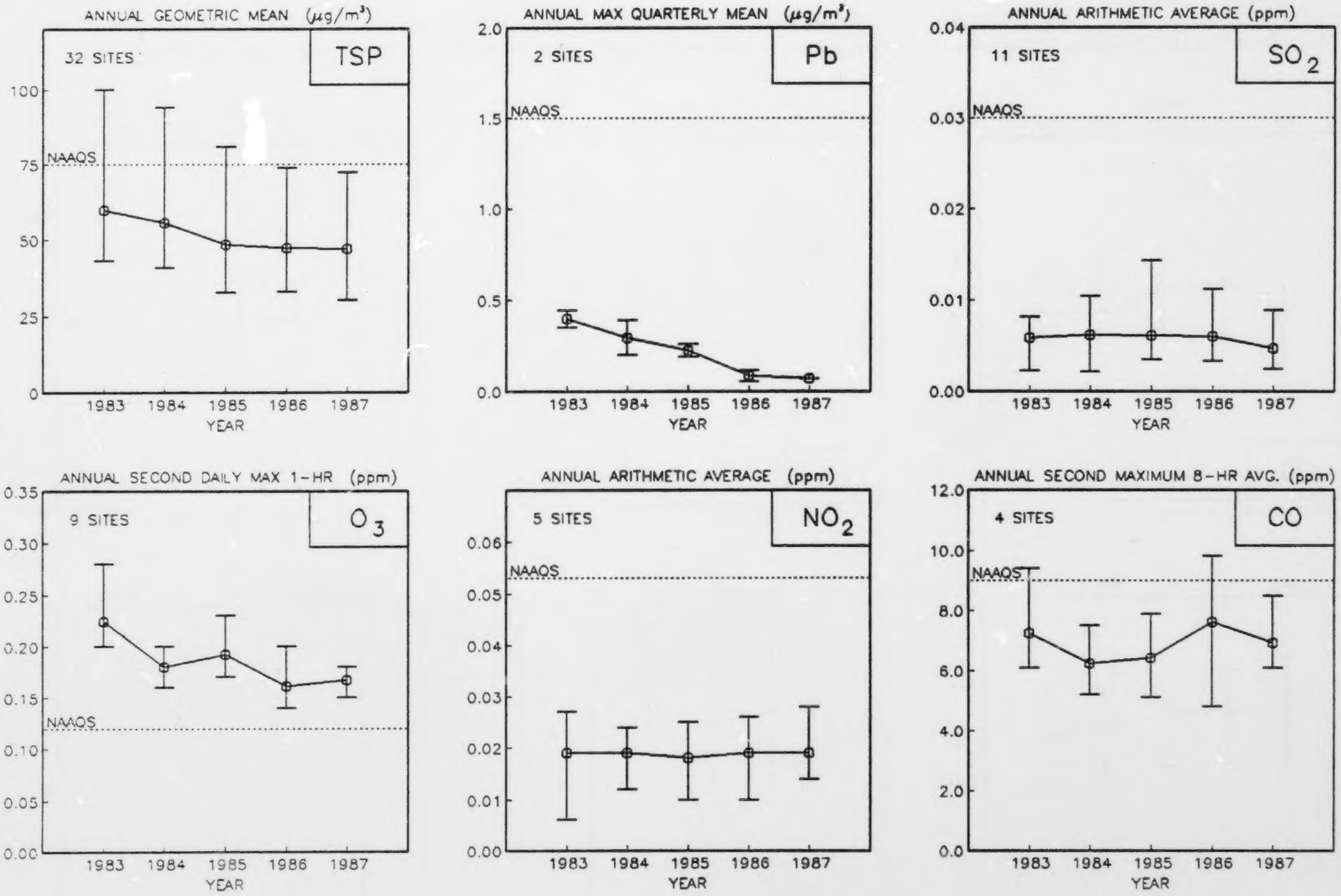

Figure 5-9. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Houston - Galveston - Brazoria, TX Consolidated Metropolitan Statistical Area, 1983-1987.

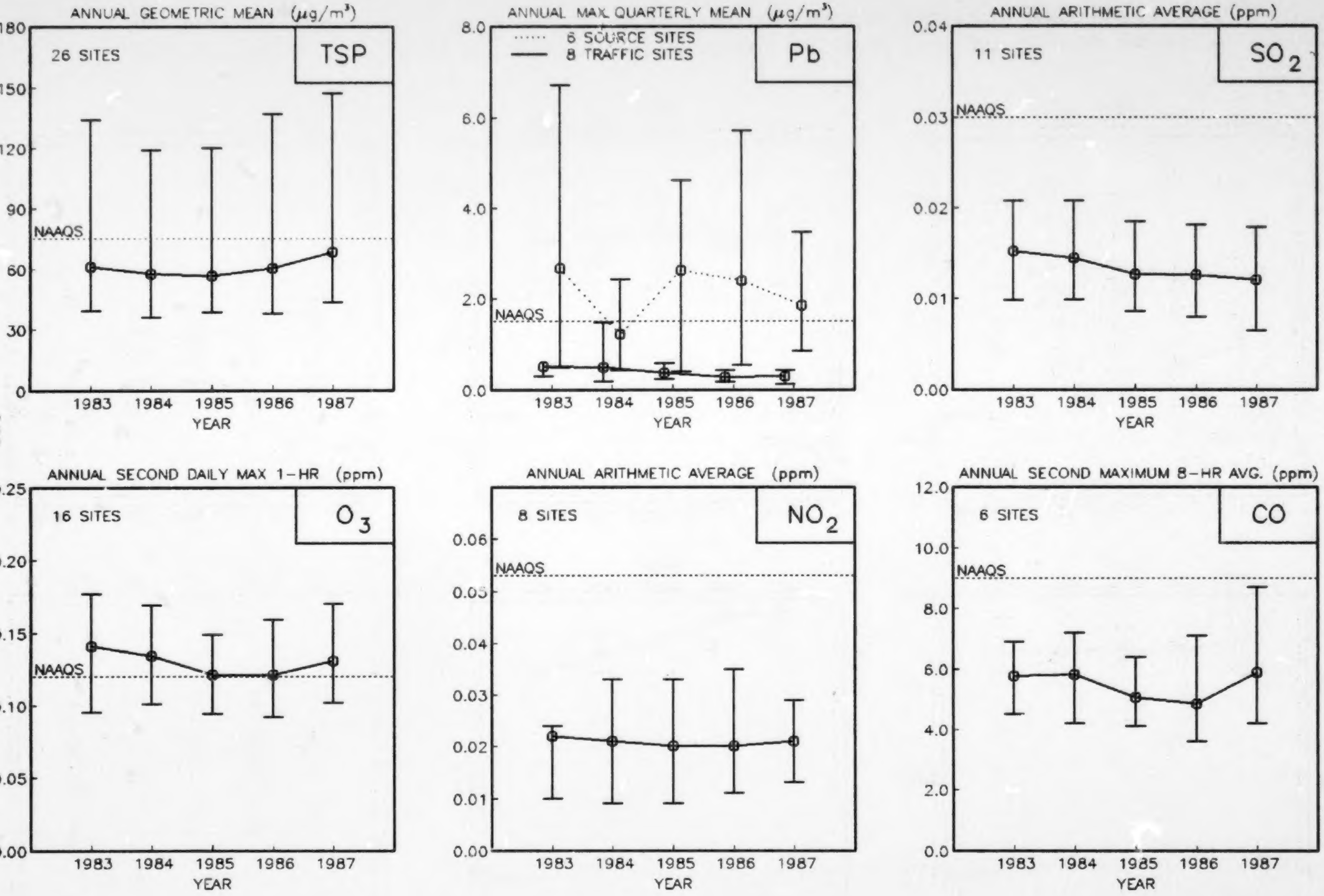

Figure 5-10. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the St. Louis, MO-IL Metropolitan Statistical Area, 1983-1987.

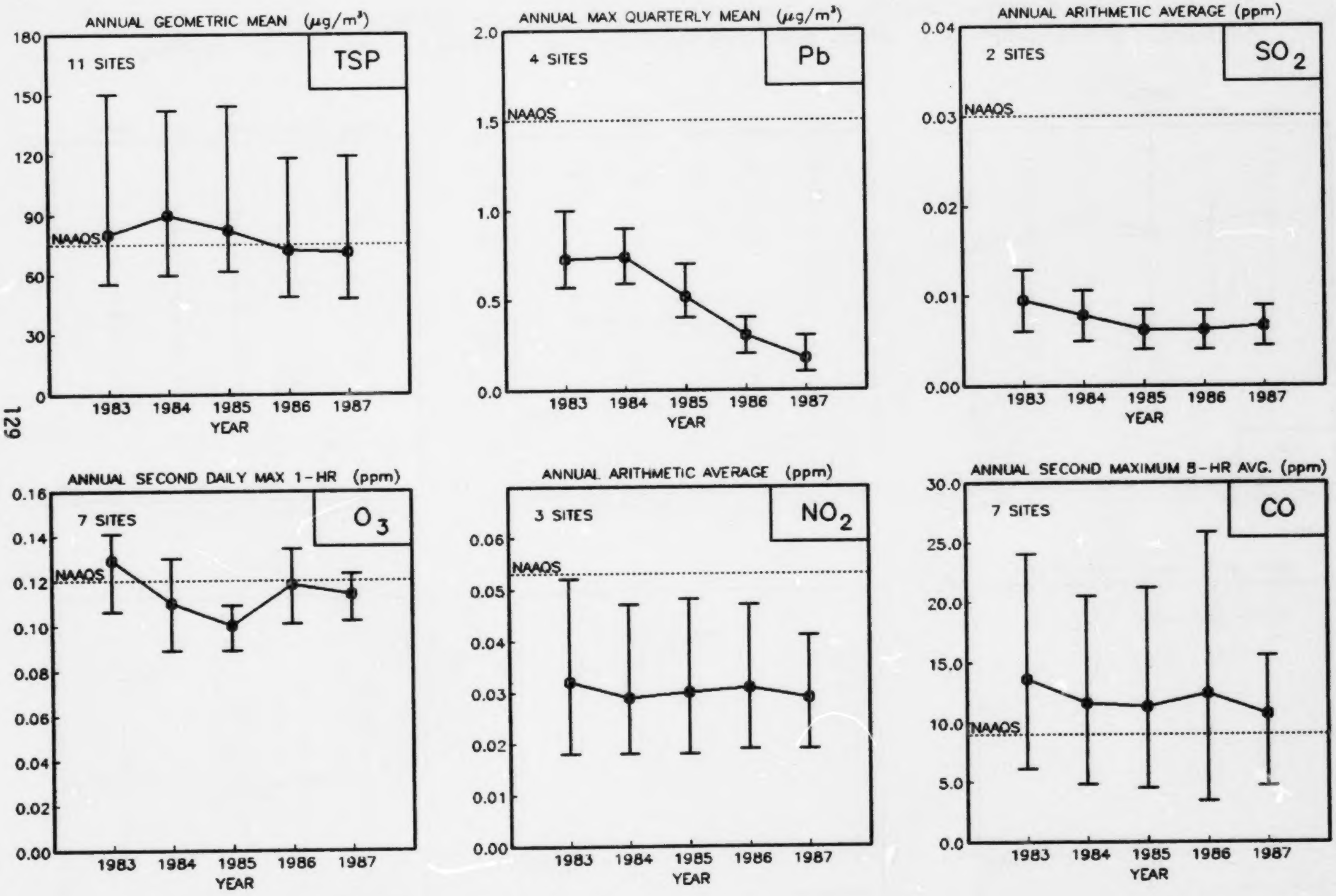

Figure 5-11. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Denver - Boulder, CO Consolidated Metropolitan Statistical Area, 1983-1987.

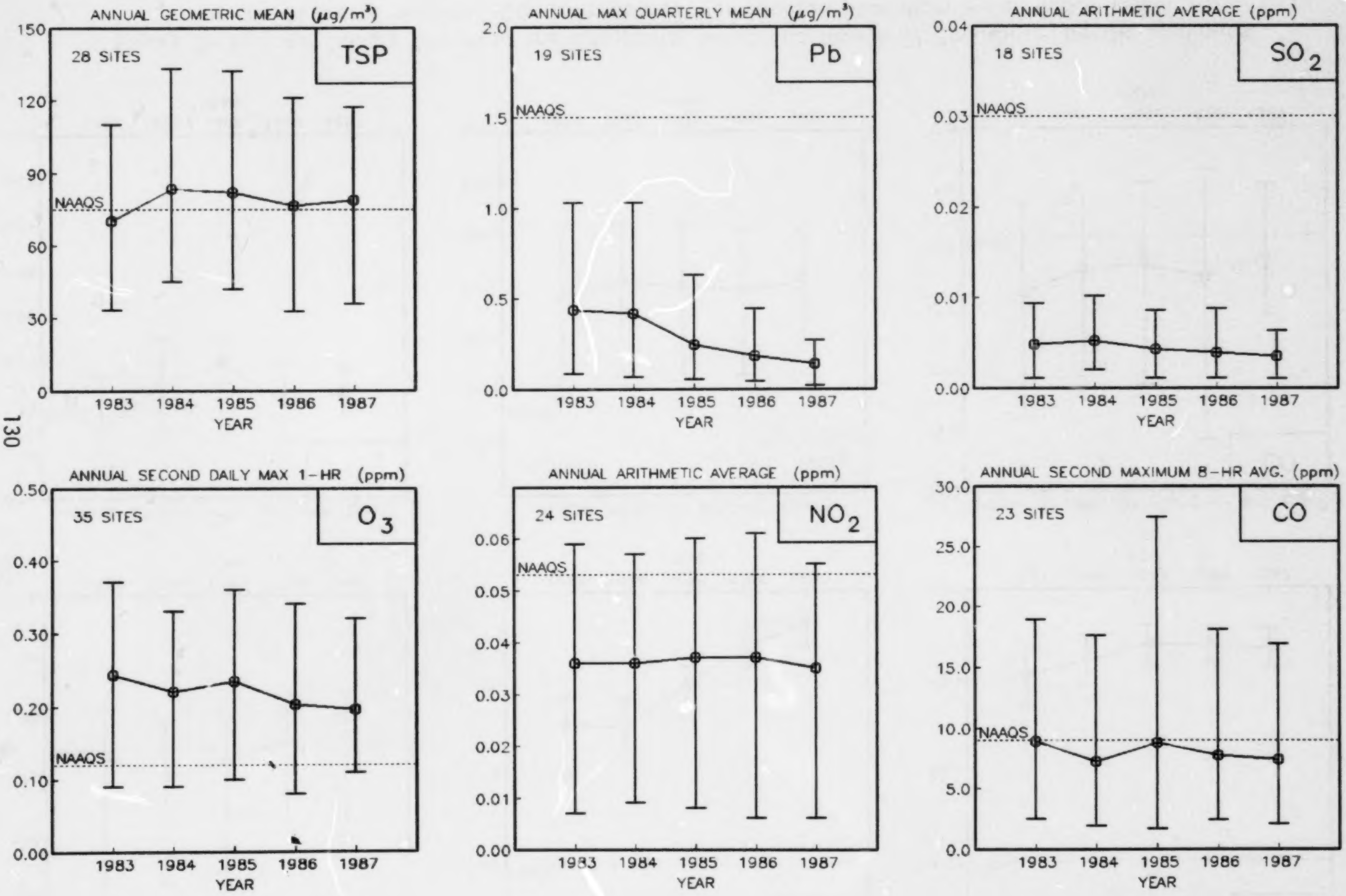

Figure 5-12. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Los Angeles - Anaheim - Riverside, CA Consolidated Metropolitan Statistical Area, 1983-1987.

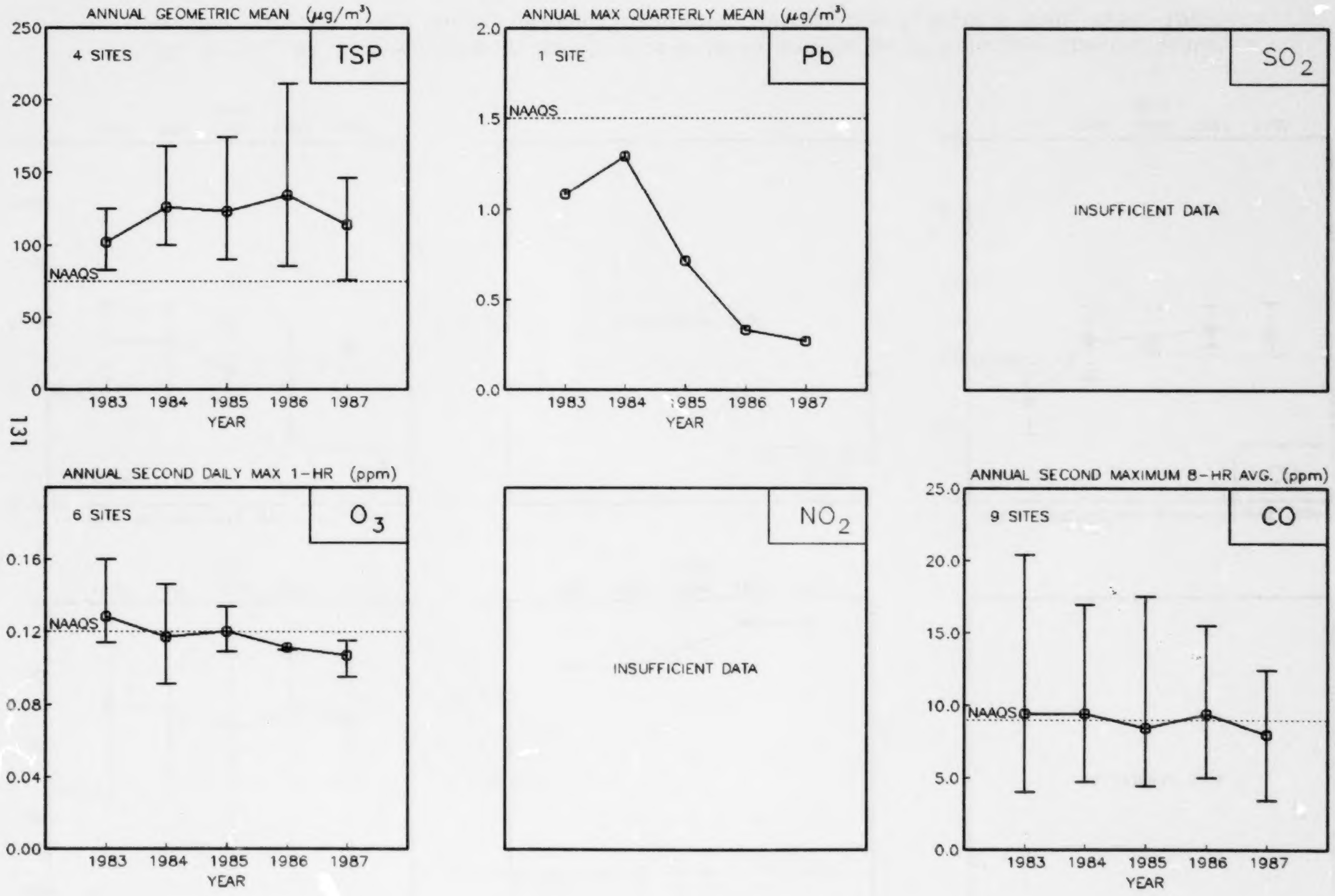

Figure 5-13. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Phoenix, AZ Metropolitan Statistical Area, 1983-1987.

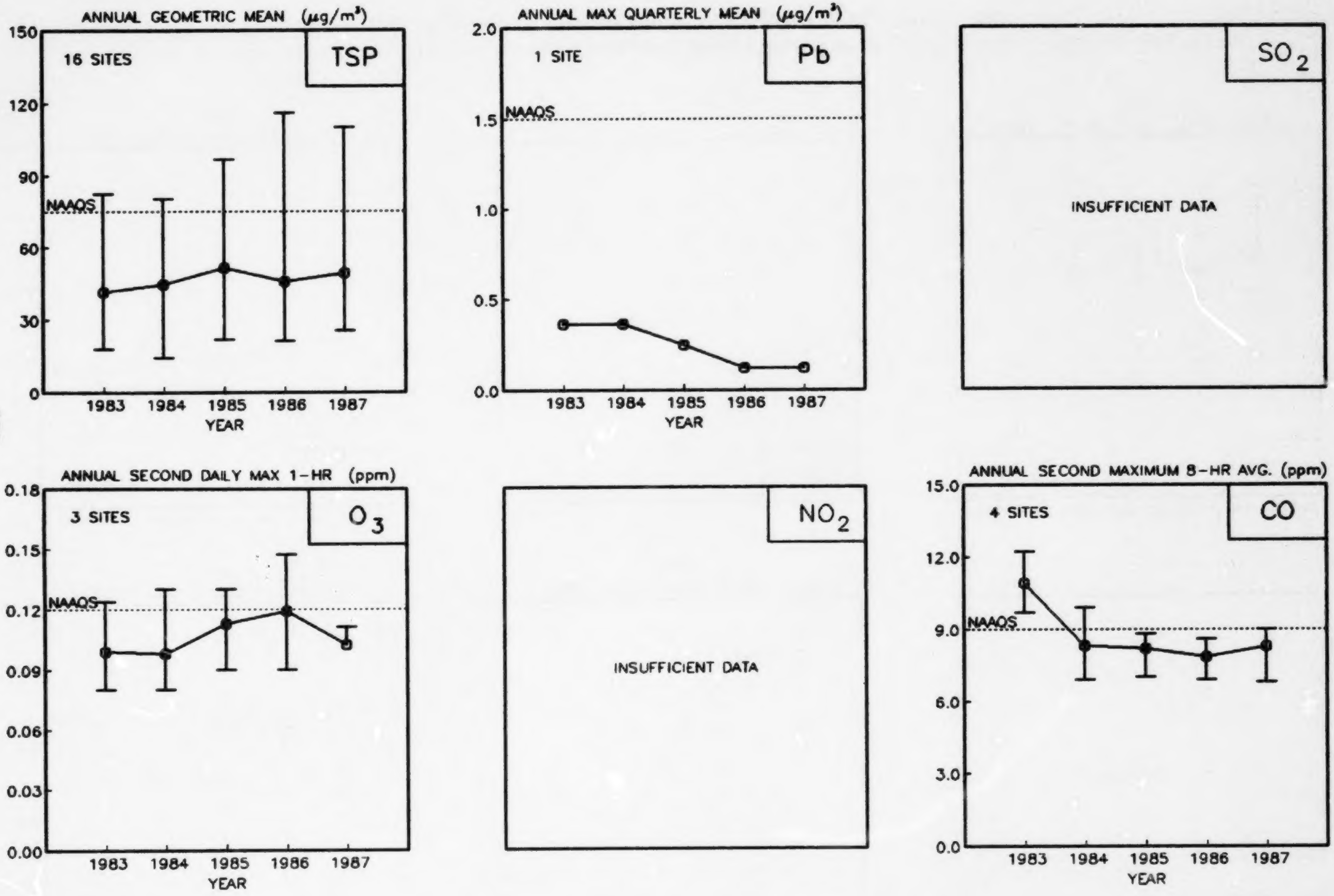

Figure 5-14. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Portland - Vancouver, OR-WA Consolidated Metropolitan Statistical Area, 1983-1987.

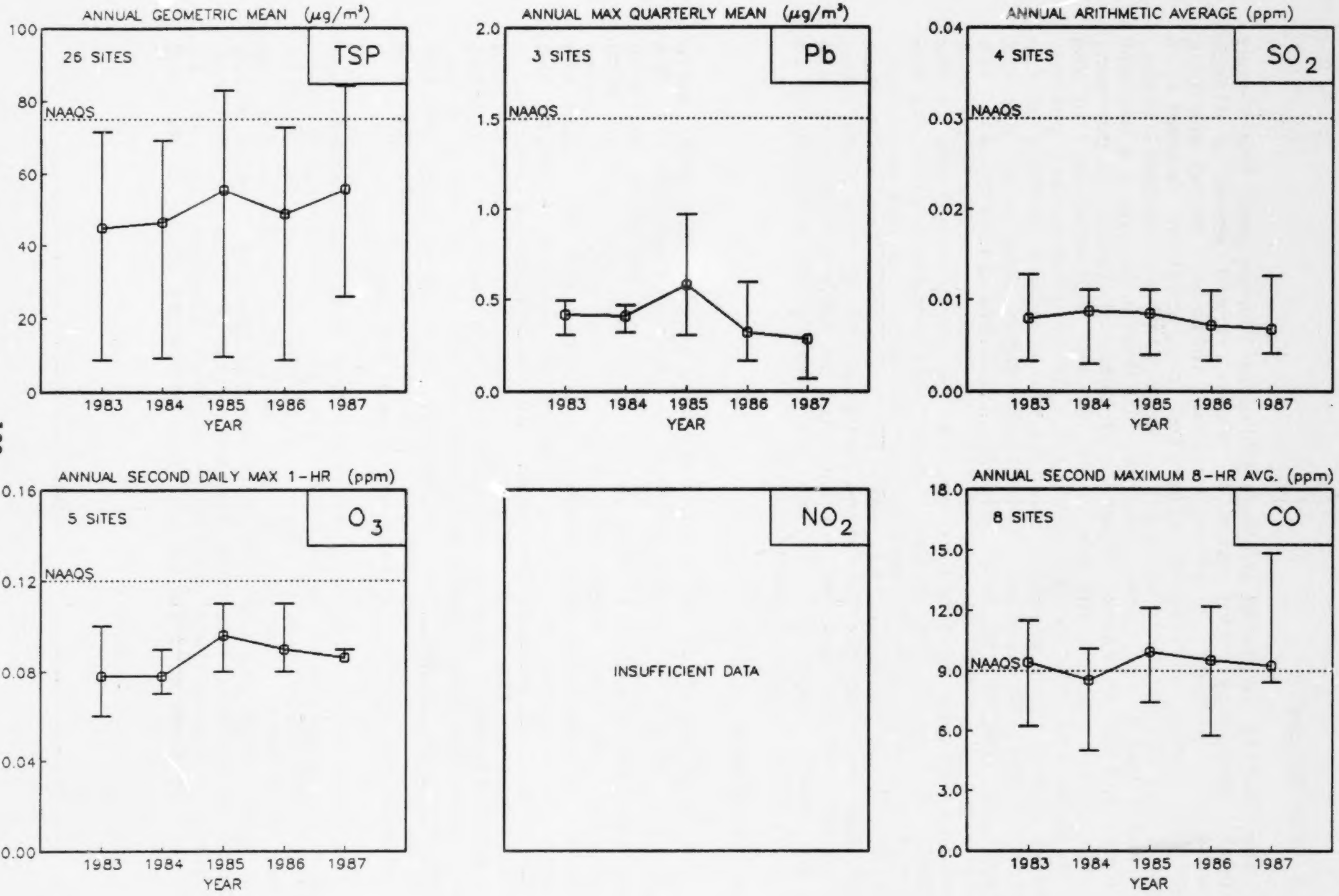

Figure 5-15. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Seattle - Tacoma, WA Metropolitan Statistical Area, 1983-1987.

5.1.1 TSP Trends

The 14-city weighted average shows no change over the 5-year period. Similarly, the national 5-year trend shows a slight decrease of 1 percent in average concentrations. Among specific geographic areas, the South exhibited the greatest decrease, 6 percent, and the East had no change. Reversing the national trend, the Midwest had a 1 percent increase, the Southwest had a 4 percent increase, and the Northwest showed a sizeable increase, 21 percent, over the last 5 years. The Northwest, showed increases in 3 of the last 5 years and are in the midst of a drier than normal period. Although the 14 city weighted average was within 1 percent of the national trend, the individual cities ranged from a 21 percent decrease in Houston to a 24 percent increase in Seattle. The decrease in Houston is attributed to their converting most industrial boilers from oil to gas in the early 1980s and to the shutdown of a major TSP source. Also, the economic slowdown has resulted in a decrease in construction projects. In the Northwest, particularly in Seattle, the years 1985 and 1987 were drier than normal and seem to be the prime contributor to the increasing trend. Also, there has been an increase in forest fires over the past few years, especially in the West, which has contributed to increased particulate concentrations.

5.1.2 Pb Trends

The national trend for lead shows a 70 percent decrease, while the 14-city weighted average shows a 66 percent improvement. The South has the largest decrease, an average of 83 percent, followed by the East and Southwest with 70 percent each, the Midwest with 59 percent and the Northwest with a 49 percent decrease. Individual cities with improvements substantially less than the national average are St. Louis, with a 33 percent decrease and Seattle with a 31 percent decrease. In St. Louis the lower drop is attributed to the relatively high point source-oriented lead sites which showed a smaller decrease than the automobile oriented sites. When the trend was restricted to roadway oriented sites, the decrease was 44 percent. In Seattle, only three sites met the trends selection criteria, and one of them was source-oriented and located near a toxic waste site which emitted lead.

The trend graphs for New York show that the lead standard was exceeded for a source oriented site. The site is in Orange County, New York which is outside of the New York MSA, but was included in the New York CMSA. Because of less stringent criteria for the trends graphs than for the Section 4 MSA air quality levels, which are based on the AIRS data completeness criteria of 12 observations per quarter, the maximum quarterly average plotted for 1987 in Figure 5-3 is from a different quarter than that shown in Section 4.0.

5.1.3 SO_2 Trends

The weighted average of the 12 cities with data yielded a 16 percent reduction in SO_2 levels compared to the 9 percent national average improvement. The cities displayed air quality results ranging from 30 percent improvement in Denver to no change in Boston. The average concentrations for Boston correlate very closely with the emission trends for the area. The East had the smallest decrease, 8 percent, and the Northwest, Midwest and South had respective decreases of 14, 17, and 20 percent. The Southwest had the largest decrease of all, at 28 percent.

In general, the areas which show a greater decrease than the national average are in the Sun Belt and energy producing areas of the country rather than in the industrialized northeastern portion of the country. The recent downturn in the oil producing/refining industry and the reduction in the primary and secondary metal smelting processes could account for these areas all having a greater than the national average decrease for SO_2 levels.

5.1.4 CO Trends

The national downward CO trend of 16 percent was closely reflected by the 14-city weighted average downward trend of 19 percent. Almost all of the 14 cities had a decreasing trend with St. Louis as the lone exception, showing an increase of 2 percent. The slight increase in St. Louis is a result of two sites which showed an increase in the 1983 through 1987 period which overshadowed the decrease over the 1983 through 1987 time period of the other 4 sites used in the trend analysis. The bulk of the change came from a rural site located next to the parking area for a community college. The CO levels recorded at this site are all well below the standard and the 1986 through 1987 increase is probably attributable to a change in parking patterns at the community college. It should be noted that none of these St. Louis trend sites exceeded the CO standard, although a new site did exceed the NAAQS. The improvement in the CO air quality ranged from 2 percent for Seattle to 38 percent for Boston. Regionally, the East exhibited the greatest downward trend of 27 percent, while the rest of the geographical regions all had trends similar to the national average.

5.1.5 NO_2

The national trend for NO_2 was a 2 percent air quality degradation over the last 5 years. The 14-cities weighted average showed no change over the last 5 years. The individual cities were mixed with four showing an increasing trend, five showing a decreasing trend, one showing no change and four cities failed to have an NO_2 monitor meet the selection criteria for the calculation of a 5-year trend. On a regional basis, the East had the greatest deterioration of NO_2 levels, with a 10 percent increase, followed by the South, with a 7 percent increase. The Midwest had a less than 1 percent improvement, and the Southwest showed the greatest improvement, with a 6 percent decrease in NO_2 concentrations. The Northwest was not included in the trend analysis because none of the NO_2 monitors met the selection criteria.

The degradation in the East is primarily driven by a 33 percent increase in Boston and, to a lesser extent, by a 13 percent increase in Baltimore. Both these trends are primarily caused by one site in each city in 1983 which records a lower than typical value. The increase in the trend at that particular site in Boston is by itself, 46 percent. If 1984 is used as the base year and the most recent 4 year trend is calculated, the trend in Boston changes from +33 percent to -3 percent. Similarly, the Baltimore trend changes from +13 percent to +4 percent. The only other city with a large increase is Atlanta, which appears to be a steady incremental increase over the last 5 years. The trend is based upon only two monitors, each one well below the standard and among the lowest in the 14-city trend section.

5.1.6 O_3

The national trend for 1983 through 1987 showed an improvement of 8 percent, while the 14-city weighted average showed an improvement of 12 percent from 1983 through 1987. This compares with a 7 percent improvement reported in last year's trends report,[2] based on the 1982 through 1986 period. This apparent improvement in the consecutive 5-year trends is explained by the fact that the base year of the most recent trend, 1983, was by far the worst year for ozone levels during the trend periods. Based upon preliminary 1988 ozone data, a 5-year comparison between 1984 and 1988 could show a reversal in some areas. For the 1983-87 period, the Southwest region had a 16 percent improvement in ozone levels, the South improved 14 percent, the East 9 percent, and the Midwest 8 percent. The Northwest region was the only area in which 1983 (the base year for the 5-year trend) was not the highest year. In fact, the West in 1983 had lower concentrations than in 1982. Consequently, the Northwest showed an 8 percent increasing trend over the past 5 years.

5.2 REFERENCES

1. Statistical Abstract of the United States, 108th Edition, U. S. Bureau of the Census, Washington, DC, December 1987.

2. National Air Quality and Emissions Trends Report, 1986, EPA-450/4-88-001, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, February 1988.

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